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THE first *Journal* cover picture shows Her Majesty the Queen on the occasion of her visit to inaugurate subscriber trunk dialling, at Bristol Central exchange on the 5th December 1958. With Her Majesty are H.R.H. the Duke of Edinburgh, the Postmaster General and Sir Gordon Radley. The article by Mr. J. A. Lawrence on p. 10 gives an account of the s.t.d. system

The President and Council send good wishes for the New Year to all members of The Institution, and with these greetings the Secretary and members of his staff would like to be associated

Secretary W. K. BRASHER, C.B.E., M.A., M.I.E.E. *Editor* W. G. ASKEW, M.C.

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S. E. GOODALL PRESIDENT 1958–1959

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PROUD OF OUR PART

It has been the pleasant practice for some years for the *Journal* to afford space in the January issue for a Presidential message to all members of our Institution. This year I am very glad to have the opportunity and privilege of sending a New Year message to my colleagues in the profession.

Our primary function is to translate scientific progress into practical benefit, not for members alone but for the greater comfort, convenience, pleasure and prosperity of mankind as a whole. It should be a constant encouragement to us that so little of our effort is directed towards other and less desirable ends.

Whether we, as individuals, are engaged in the manufacturing industry, in operation, in consulting, in teaching, in research or in some other electrical activity, we are all concerned with 'the general advancement of electrical science and its applications' and, as such, have the potentiality of making a useful contribution to the betterment of man's lot.

Now, more than ever before, our work is playing its part in the improvement of standards of life in some of the less developed countries of the world, and this, in particular, should be regarded with justifiable pride.

To the young man about to join our great profession, I would like to stress the importance of my preceding remarks and to extend a very sincere welcome on behalf of all our senior members. Great things have been achieved, but even greater ones are possible with your help. I hope you will accept the challenge and so share in the satisfaction that comes from doing a man-sized job really well.

Many of the activities initiated by the electrical engineer are now becoming such enormous projects that large teams of workers of all types are required to carry them through. In addition, the range of electrical development is constantly increasing. For both these reasons the demand for professional electrical engineers is growing rapidly.

There have been several attempts in recent years to assess future demands and to estimate how far these demands are likely to be met from existing sources of supply. Whatever actual figures have been obtained by these exercises, one common conclusion has been reached, namely that we are seriously short now and may be even more so in years to come.

As you know, your Council have given this problem the serious attention it deserves for some long time and have taken every possible step to bring the shortage to the notice of schools, technical colleges, universities, Government circles, and other interested parties, not forgetting parents and boys and girls. It was with considerable pleasure that we noted recently the first awards of the new Diplomas in Technology (Engineering) by the National Council for Technological Awards. As the numbers increase year by year, it is anticipated that a further worthwhile contribution will be made by the principal technical colleges. The universities also are providing more places for engineers, and the primary need now is to persuade greater numbers of intelligent young people to join us.

Those of you who have visited Headquarters lately will, no doubt, have noticed that building operations have begun. Completion will be effected as quickly as possible, and I hope that you will all share with me pride in possession of a building with up-to-date and convenient public and administrative accommodation. Our Lecture Theatre, in particular, will be very greatly improved, although we shall not be able to complete this part of the alterations until 1960.

In conclusion, I should like to wish all my fellow-members a happy and prosperous New Year.

THE PRESIDENTIAL ADDRESS

Electric cables 621.315.21

This is a condensed version of the Address delivered by Mr. S. E. Goodall, M.Sc.(Eng.), F.Q.M.C., on the occasion of his inauguration as President of The Institution on the 9th October 1958 (see p. 7). The complete text and illustrations will be published in both Part A (February 1959) and Part B (January 1959) of the Proceedings.

At this moment in the career of a newly elected President of our great Institution, he stands before his friends with feelings so complex that they are not easy to analyse. I can only express my very sincere appreciation of the signal honour conferred on me. I will do my utmost in the year ahead to uphold the high traditions and standards established by the many distinguished men who have done so much for our corporate body in previous years. Quite apart from their technical and professional ability, they share one distinction in common: they have been and are always ready to encourage and help the younger man. This is a tradition which is among the finest cherished by our Institution.

Last year on this occasion we were treated to a masterly exposition of the incredibly rapid growth of one of our modern branches of industry—that concerned with radio valves. Mr. Goldup chose as his significant date 1904. I make no apology for choosing a somewhat earlier date as my reference point: 1812. For it was in that year that Sommering and Schilling conducted a series of experiments in which a soluble material, said to be indiarubber, was first used for insulating wire.

It is not my intention to attempt to provide anything like a complete history of the early days of cable making, but it may not be without interest to highlight a few of the important early events.

First telegraph cables

In 1831, Michael Faraday enunciated and demonstrated the laws of electromagnetic induction and thus made possible the generation and distribution of electrical energy. For the first time, it became apparent that cables would be required for such purposes, as well as for submarine telegraphic communication.

Meanwhile, contemporary scientists and engineers were devoting a great deal of thought to the new technology of telegraphy, and schemes for achieving long-distance communication were receiving active consideration.

By the middle of the century, a number of successful telegraph systems were operating in this country. Practically all the lines were overhead, and where underground installations were adopted much trouble, due to ingress of moisture, was experienced. Meanwhile, the newly discovered natural gum, known as gutta-percha, had been introduced into this country and used for a variety of purposes, mostly domestic.

By 1851, the first cross-Channel telegraph cable was successfully laid. By this time also, several manufacturing companies producing both telegraph instruments and cables were established, and two or three of these were to survive as household names to this day. Then followed the magnificent achievement which was to establish British supremacy in submarine-cable work for the next hundred years, and maybe more. After two tragic and expensive failures, a successful transatlantic cable was laid in 1866 by a company formed to do so.

By 1871, there were sufficient engineers in this country directly concerned with telegraphy to render it desirable for them to form a learned society of their own for the purpose of discussing their mutual technical and scientific problems. In that year, the Society of Telegraph Engineers was formed, and the first meeting took place in 1872.

Almost from the inception of the new Society, it became apparent that the interests of electrical engineers would not be restricted to telegraphy alone. In 1888, the Society was renamed The Institution of Electrical Engineers, a choice which has stood us in good stead for the last 70 years and which we trust will continue to serve the needs of succeeding generations for many years to come.

Meanwhile, the use of electricity for lighting was beginning, and attention was focused on the possibility of distributing power underground. During this period, many of the systems developed did not use cables but employed conductors supported on insulators in ducts or trenches. Where cables as such were employed, rubber soon achieved recognition as one of the best insulating materials.

Early power cables

It was the pioneer work of the young Sebastian de Ferranti that really blazed the trail for the development of power cables as we understand them today. In 1887, as chief engineer of the newly formed London Electricity Supply Corporation, at the advanced age of 22, he was responsible for the conception and design of the first large London power station at Deptford.

Ferranti was soon dissatisfied with existing types of cables and designed and superintended the manufacture of an entirely new cable for his mains. In doing so, he produced the first high-voltage impregnated-paper power cable: a type which, although the subject of research

and improvement over the years, has remained practically unchallenged until recently.

By 1900, single-core and 3-core impregnated-paper lead-sheathed cables of various designs were being supplied by several manufacturers, and demand was growing rapidly.

We have seen how the demand for lighting created a need for cable development. The telephone, invented in 1876 by Alexander Graham Bell, soon posed an entirely new set of problems to the cable engineer. The necessary development was made very quickly indeed, after an initial period of neglect of the basic principles.

Although cable manufacture for telephonic communication proceeded apace from about 1890, it was many years before telephone cable engineers understood and began to apply the brilliant theoretical work of Oliver Heaviside, published in 1885–87. His emphasis on inductance was to remain ignored until Pupin in the United States evolved practical means of adding inductance to telephone cables. He added 'Pupin' coils at intervals to the lines, thus achieving artificial loading.

The alternative of continuous loading by laying iron wire along the whole length of the copper conductor was introduced by a Danish engineer, Krarup; and short lengths were made by the Germans in 1902. The first British-made cables of either type did not appear until 1910. The first cables used for telephony were insulated with gutta-percha as they were merely adaptations of telegraph cables. In the search for lower leakance, an alternative material, balata, was brought from South America.

Meanwhile, telephone connections between towns and cities were established mainly by overhead lines, while multi-circuit cables soon became necessary in the towns. So lead-covered cables were introduced, at first filled with insulating material, such as paraffin wax, but soon greatly improved by the adoption of the dry-core technique, where the individual wires are covered with dry paper and advantage is taken of the air interstices to obtain low capacitance.

By the beginning of this century, covered conductors and cables were needed in great variety for many purposes, and this need has extended over the last 50-odd years.

Development to meet many needs

On the power-cable side, the growth in power generated and transmitted has led to a continual increase in both voltage and current requirements for cables. As voltages increased it became apparent that special means would be required to prevent or suppress ionization within the cable dielectric if any length of service was to be achieved. At first, progress was made in improved impregnation methods and materials and in stress control, particularly by screening; but this was not sufficient to remove the inherent electrical weakness arising from the effect of heating cycles.

The first effective solution to these problems was found by Emanueli in 1920. He used a thin mineral oil under pressure from reservoirs at predetermined points in the system. Cables of this type are manufactured in this country by three or four of the leading cable companies, and the majority of the highest-voltage installations, both here and abroad, employ this system.

The alternative of using high-pressure gas to suppress ionization was first conceived by Fisher and Atkinson in 1920 and patented in the United States in 1925. Many years elapsed before there was any exploitation of these ideas in America. In Great Britain, however, four of the major cable companies evolved solutions of the many practical problems. Although development was seriously interrupted by the Second World War, there are now many important installations employing these types of super-tension cable.

One other main preoccupation of the cable maker during this period deserves particular mention: the development of cables for wiring houses, public buildings and industrial premises. The earliest installations were wired with conductors insulated with paraffined cotton, but this material was soon replaced by rubber mixtures of varying efficiency.

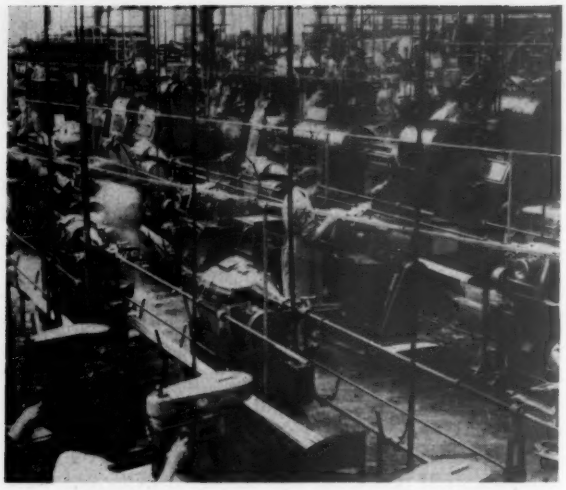
By June 1882, there was enough concern about the risk of fire to justify the preparation, by the Society of Telegraph-Engineers and Electricians, of their first 'Rules and regulations for the prevention of fire risks from electric lighting'. In 1897, a new set of 'Fire rules' was published. This was prepared by a technical committee comprising the whole Council, together with other experts. It was now concerned, not only with lighting, but with the supply of electrical energy.

Various systems of wiring were being advocated, and from these emerged two which were to survive the test of time: the steel conduit and the lead-sheathed systems. Great improvements were effected in the production of appropriate rubber compounds, in the methods of applying the insulant and sheath, and in the subsequent vulcanization process.

Another group of cables has been required for signalling purposes, first, of course, for the railways. The First World War created a much larger demand for cables of this type, but there were no other notable changes in technical requirements in 1914–18. The normal products of the industry, however, continued in great demand throughout the war.

Between the two wars, although considerable technical progress was made, there was no radical change in the materials used. There was keen competition and a gradual increase in the number of companies engaged in cable work; but trade expanded steadily both at home and abroad, except, of course, during the general trade slump in the early 'thirties.

During the process of expansion in cable business, both in quantity and type, parallel needs had developed for the many fittings, accessories, pillar units, fuse units, joint boxes, sealing ends, etc. that were required. This has now become a highly technical and specialized trade in itself. Some slight indication of the importance of this activity may be gathered from Fig. 1, which gives a



1 *General view of a factory producing accessories*

general view of a factory devoted solely to this class of work.

The Second World War had far greater effect on the work of the cable engineers than the first had done. The initial impact was a sudden demand for high-frequency cables for radio and radar application. Great accuracy and consistency in manufacture became essential, and the new plastic material, polythene, came into the picture.

The difficulty of obtaining adequate supplies of raw rubber necessitated a rapid examination of the possibilities of synthetic materials, including the now well known polyvinyl chloride (p.v.c.).

Recent changes

Up to the beginning of the war, certain basic materials and processes had become so well established that it had begun to look as though they would never be seriously challenged. Since the end of the war, however, the position has changed very drastically, and I propose to direct attention to some of the more important of these changes, which have had a profound effect on the general economy of cable making.

The first example is concerned with the manufacture of the smaller sizes of rubber-insulated and -sheathed cable, familiar in domestic applications.

The well established method of covering, usually called 'longitudinal', includes these processes: After preparation of the appropriate rubber compound in the form of slabs, a calendering process produces thin uniform sheet. This sheet rubber is cut into long strips which are rolled up and mounted, so that they can be fed in pairs between grooved rollers. The wires to be covered are passed through the rollers in the grooves and between the two strips of rubber.

Subsequently, the covered wires, or cores, are rewound onto drums which are wheeled into a large vessel into which low-pressure steam is fed to effect vulcanization of the rubber. This method is far from efficient, involving as it does several discontinuous processes, particularly at the longitudinal-covering machine itself.

The modern alternative, developed since the war, is known as 'continuous vulcanization'. Rubber compound in the form of thick strips is fed into the hopper of a rotary-screw extrusion machine, so designed that the compound is forced onto the wire to be covered as it passes through the 'head' of the machine at a fairly high speed. On leaving the head, the covered wire passes into a long, well-lagged steel tube containing high-pressure steam.

In its most highly developed form, the plant is run continuously for a working shift of eight hours, or even longer. Any variation in the thickness of the rubber covering is immediately corrected by an automatic adjustment of speed, effected by electronic control equipment. For larger-diameter sheathing, extrusion of the rubber compound is employed, but the vulcanization is discontinuous.

Unfortunately, it is not possible to produce the whole output of small- and medium-size rubber core and sheathing by this method, owing to the large variety of size, colour and type of core and cable required.

Plastic and synthetic-rubber materials

Of the several plastic materials produced in the last 20 or so years, p.v.c. has so far proved the most important for general cable-making purposes. Direct extrusion is employed for both core and sheath of a wide variety of cables, many of which were formerly produced solely by using rubber. The preparation of p.v.c. compounds for the different purposes required by users is a highly complex and specialized operation.

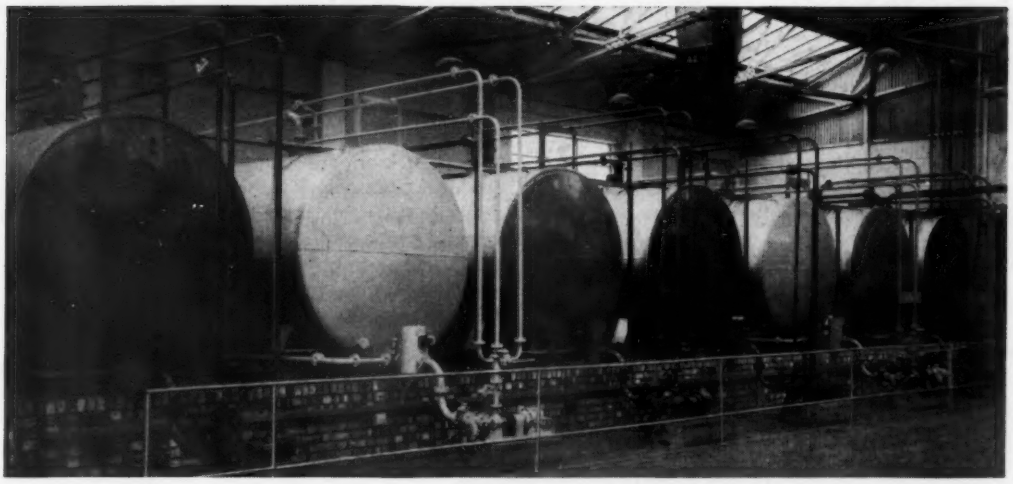
Those cable makers who use large quantities and/or supply special-purpose cables find it desirable to purchase the ingredients and evolve their own compound formulae. In addition to the elaborate mixing plant, equipment is necessary to produce the compounded p.v.c. in suitable pellet or granule form for feeding into the extrusion-machine hoppers. Figs. 2 and 3 show one of the most modern plants recently installed for the preparation of p.v.c. compounds.

The other important plastic material is polythene. For such purposes as house wiring, fairly large quantities of cable have been used in this country, the polythene core being protected by p.v.c. sheath.

Fortunately for the cable makers, relatively minor modifications to p.v.c. extrusion plant are required for the production of small polythene core. The fact remains, however, that they are now producing at least three varieties of these cables employing different materials for the same conditions of service.

Ordinary grades of polythene melt at slightly over 105°C, so that cables using this material are more prone to damage by sustained overload or short-circuit.

P.V.C., on the other hand, becomes softer as the



2 *Storage vessels for raw materials in a p.v.c.-compounding plant*

temperature increases and, while it has no sharp melting-point, is subject to the disadvantage that serious deformation under mechanical stress could occur at the higher temperatures. Neither material is able to withstand the overload conditions that can be tolerated by vulcanized rubber, without serious consequences.

Polythene has also been employed successfully for higher voltages up to 11 kV, although very restrictedly in this country up to the present.

In addition to plastic materials, a number of synthetic-rubber materials are now available. Polychloroprene is used where good resistance to oil and water is required. It also has the advantage that flame does not spread along it. It is, however, inferior electrically and is usually employed for sheathings and not as a dielectric. Fortunately, plant and process problems are minor.

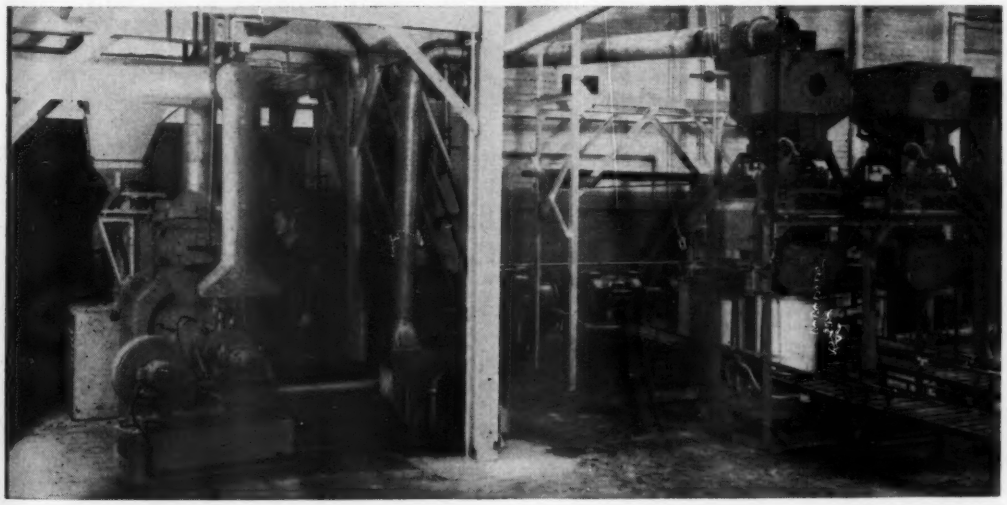
Butyl rubber, a copolymer of *iso*butylene and isoprene, is receiving increasing attention. It is resistant to oxidation and is of low chemical reactivity. Processing is, however, by no means simple.

Another particularly important synthetic is silicone rubber. It has certain unique advantages and is being used in H.M. ships and in aircraft. It has exceptional resistance to heat and operates indefinitely at 150°C, and at considerably higher temperatures for short periods. After a fire, cables continue to function if not disturbed, as the residue is largely pure silica. Flexibility is retained down to −70°C.

The outlook for the future

From the foregoing examples, it will be evident that there has been a considerable strain on the cable makers' capital resources since the war and that the demand by the industry for highly specialized scientists and technologists has increased materially.

In one respect the cable-making industry, and indeed the whole electrical industry, of this country have been fortunate. We have been assured of an ever-increasing home market on which to base a flourishing export



3 *Equipment for making p.v.c. compounds*

business. Modern political trends, however, suggest that we may soon be facing Continental competition in our home market.

One important consideration, namely that of standards, is worth examination. British Standards are the basis on which many Commonwealth countries have developed and are developing standards to meet their own requirements. On the Continent, there are one or two sets of standards which are different from our own in many respects. At the present time, much attention is being devoted to the possibility of reconciling these differences in whole or in part. My own view is that the British cable user would be most unwise to agree to such drastic changes without very careful consideration of all the detailed factors involved.

And now, what of the outlook for cable making in Great Britain? First, let us look at some of the technical possibilities and objectives.

Commencing with power cables for distribution purposes, the demand for the comparatively new non-draining paper cable has built up rapidly. This is the type in which the impregnant is a waxy material, solid at operating temperatures.

Plastic mains cables

Meanwhile, considerable interest is being shown in plastic mains cables. P.V.C. has, of course, been used for some years for low and medium voltages for industrial installations. The Area Boards and the Cable Makers Association have been engaged recently in a joint study of the potentialities of p.v.c. mains cables, and a draft specification has been submitted to the B.S.I.

Any plastic is likely to be inferior to paper in severe overload or short-circuit conditions. It may be some time before these cables are used extensively in this country, though I am confident that we shall see some installations of appreciable magnitude in the near future.

At higher voltages, up to 11 kV, polythene has been used successfully as a dielectric material despite the difficulty of ensuring an entirely void-free extrusion.

There has been discussion recently in national and international circles concerning the use of polythene for very high voltages. At present it appears unlikely that any extruded plastic material will be used for such purposes except for submarine cables, where polythene may well offer some advantages, particularly for direct-current transmission.

For modern conditions of greater power and higher voltages, it is evident that the highly developed oil-filled cable system can meet all requirements likely to arise for many years to come. Within limits, this is also true of some designs of gas-filled cable.

The drive for economy in use of materials in the manufacture of cables is running parallel with the drive for economy in the use of the cables themselves. It is by no means simple to state appropriate limits in practice, as most cables are subject to varying loads, often in a daily cycle. They may also be subject to overload for long or short periods, particularly in emergency, and may have to carry occasional short-circuit currents of considerable magnitude for times dependent on the rate of operation of the protective apparatus.

In view of the necessity for national economy in such matters, some important investigations on cable utilization are being conducted by the Electrical Research Association in conjunction with the Central Electricity Generating Board, the Area Boards and the cable makers.

Future developments in cables for wiring are unlikely to be revolutionary. The trend towards greater use of plastic materials will undoubtedly continue.

Much attention is being paid to the development of cables for extremely arduous conditions, such as are met in aircraft. Some of the latest types of cable for these duties are proving very successful in service, and there is little doubt that even the most difficult conditions imposed by aircraft designers will effectively be met.

Expansion of the use of silicone rubber for applications where higher-temperature operation is desirable, and/or where temporary operation after fire is required, will no doubt occur. For most purposes, it will be necessary to protect the insulation, as the material is not resistant to some fuels and lubricants.

Improvements in p.v.c. compounds will extend the usefulness of this material, particularly for operation at slightly higher temperature without material reduction in useful life.

Alternatives and variety

It will be evident that the two bugbears of cable making are alternatives and variety. By this I mean alternative designs and materials for the same duties, and variety of size, type, colour, finish, etc. in the vast range of products. The former has particularly afflicted us since the last war and has led to constant demand for new and modified plant far outstripping the gradual growth in gross demand for cables. The result is that the industry as a whole now has surplus plant for many operations, although few, if any, of these operations are entirely obsolete.

If effective progress is to be maintained, two steps would appear to be necessary. First, the industry must be prepared to face the consequences of rationalization of production. Technical collaboration has improved considerably in recent years; but this alone is not enough, important though it is to improve still further in this respect. Second, the cable users, in their own and in the national interest, must be prepared to accept some measure of restriction of choice.

Finally, examination of the scientific future leads me to the conclusion that there is no fear of the art and technology of cable making becoming redundant. There would appear to be no suitable alternative to electricity capable of providing such a wide range of services, and so far there is no indication that electricity can be guided and distributed, save in very minute quantities, by any convenient means other than the electric cable.

Opening Meeting

Inauguration of new President, Mr. S. E. Goodall

This is an account of the Ordinary Meeting of The Institution at Savoy Place on the 9th October 1958, at which Mr. S. E. Goodall, M.Sc.(Eng.), F.Q.M.C., succeeded Mr. T. E. Goldup, C.B.E., as President of The Institution. A condensed version of Mr. Goodall's Inaugural Address appears on p. 2.

It was a case, almost, of 'standing room only' at the Opening Meeting of the 1958–59 Session of The Institution on the 9th October 1958. In addition to members, a number of ladies were present in the Lecture Theatre, in which rows of temporary seating had been added to accommodate the full house. While waiting for the arrival of the Council members, the audience were able to hear, above the conversation, 18th-century music over the improved speech-amplification system. With a good input to reinforce, *which it does not always get*, the system behaves very well. For some of those in the temporary seating, it was a case of good sound but no vision during most of the meeting.

The retiring President, Mr. T. E. Goldup, took the chair at 5.30 p.m., announced the donations and subscriptions to the Benevolent and Homes Funds, and gave notification of the appointment of Mr. J. R. Rylands as an ordinary member of Council to fill the vacancy created by the election of Mr. A. H. Mumford as a Vice-President before the completion of his term of office as an ordinary member of Council.

The welcoming of new Corporate Members was, because of their numbers, a lengthy but nevertheless heartwarming process; and especially warm applause was given for a new Indian Corporate Member, over whose long name the Secretary understandably paused in his announcement.

There followed the annual presentation of Premium Certificates. The longest applause of the evening was accorded to Mrs. Megaw, who received the Institution Premium on behalf of the late Dr. E. C. S. Megaw, their two sons being present.

In inviting the new President, Mr. Goodall, to deliver his Address, Mr. Goldup spoke with feeling of the *work* that falls to the lot of the President.

Mr. S. E. Goodall delivering his Inaugural Address

Mrs. Megaw receives the Institution Premium Certificate awarded to her late husband, Dr. E. C. S. Megaw

The new President is Chief Engineer of W. T. Henley's Telegraph Works Co. and a man of wide and unstinting service to The Institution. Elected an Associate Member in 1934 and a Member in 1943, his first term as a Council member began in 1941, since when he has served on the North-Western Centre Committee, the North-Western Radio Group Committee, the Supply Section Committee, and all the principal Committees of the Council. He was Chairman of the Supply Section Committee in 1950–51 and a Vice-President of The Institution from 1953 to 1958. His Address was devoted to the theme of electric cables.

Mr. Goodall's clear and articulate presentation was much appreciated, as were some of his amusing and telling interpolations, such as 'where we are tonight' when referring to the down-and-outs and homeless urchins who in the 1850's slept in their thousands under the arches of the Adelphi or Waterloo Bridge. His story of Sir William Preece, Lord Tennyson and the bugler raised the loudest laugh of the evening, but other sallies which caused much amusement included his reference to the lack of technical appreciation and leadership of the Post Office in the 1900's, particularly his interpolation 'there is no discussion on this Address'; and his feeling remark 'if only those were the Regulations today' when speaking of the first 'Rules and regulations for the prevention of fire risks

from electric lighting', issued by the Society of Telegraph-Engineers and Electricians in June 1882, in which cables are dismissed in one sentence 'All wires used for indoor purposes should be efficiently insulated'.

His colour slides were most effective, particularly one of some colour-coded tanks for liquids for making p.v.c.

Sir Josiah Eccles, in proposing a vote of thanks to Mr. Goodall, spoke of the President's reference to the reading of a paper by the Secretary in 1873 and commended the idea to the Papers Committee. He also pointed out that Mr. Goodall's reference point of 1812 for his Address was, although he hardly dared mention it, the natal year of the gas industry.

It was interesting to note that the very first cable was used to detonate mines. There was no greater instrument of destruction at that time, and there might be a crumb of comfort to those who were fearsome about the future development of nuclear energy in the realization that the successful outcome of the cable industry started in such an unpromising way.

Of the contribution of the cable industry to our well-being there could be no doubt. One had only to think of the chaos that would ensue if all the cables—telephone, telegraph and power—disappeared overnight. We should slip back to the Dark Ages, and even Sir Harold Bishop's efforts to educate and amuse, successful as they were, would be completely frustrated, both at the production and at the reception end.

Sir Josiah then asked if the electric overhead line might be mentioned as an alternative means to that postulated by Mr. Goodall in the last sentence of his Address. Members had seen their new President in action and knew now what manner of man he was. He could assure them that he was both incisive and tenacious. He needed to know the why, the how and the when of every subject under discussion. Chairmen of committees had been known to shrink visibly when the new President got busy on analysing some not-too-well-thought-out scheme. In spite of that, he had probably done more work for The Institution than any other man of his generation.

Sir Josiah said it was a very great privilege indeed for him to be permitted to propose 'That the best thanks of The Institution be accorded to Mr. S. E. Goodall for his interesting and instructive Presidential Address, and that with his permission the Address be printed in the *Proceedings* of The Institution'.

Mr. A. H. Mumford, wittily seconding the vote of thanks, obviously enjoyed 'pulling the leg' of his erstwhile colleague. While Mr. Goodall was speaking he had started to count up the eminent Past-Presidents he had mentioned. He believed he had named five, and he felt a degree of pride in thinking that three of them, at least, were light-current engineers and therefore, he supposed, direct descendants of the Telegraph Engineers—that is, of course, if the outgoing President did not mind being called a telegraph engineer for the purpose of the argument.

He particularly hoped that the emphasis on variety reduction should not be taken to mean that the customer was always wrong, because the latter in the end still called the tune. Like most Presidents, Mr. Goodall had finished up with a few intriguing thoughts and had posed a few questions which he had not attempted to answer, such as that concerned with standardization. He was sure that the Informal Meetings Committee would seize upon such crumbs as that, and they might develop this question of standardization in the Continental market and other ideas put forward about regrouping in manufacture and closer collaboration.

He thought that the President had made one or two brief references to high-frequency operation to keep him (Mr. Mumford) interested; but the President, when replying to the vote of thanks, which was carried with acclamation, averred that he had put in the references to keep Mr. Mumford awake.

After the induction of Mr. Goodall into the Presidential Chair, the vote of thanks to the retiring President, Mr. T. E. Goldup, was proposed by **Sir Gordon Radley.** He said that Mr. Goldup had toured the world for The Institution. He had represented The Institution at the fourth Conference of Engineering Institutions of the British Commonwealth, in Australia, and the sixth Conference of the Engineering Societies of Western Europe and the United States of America, in New York. Not content with that, he and the Secretary went out of their way to visit as many as possible of the Oversea Centres and Groups, so that they might make members there more aware that they belonged to The Institution and were part of the family.

There was a verse in Proverbs which said 'Seest thou a man diligent in his business? he shall stand before kings'. He did not think that Mr. Goldup had quite done that, but he had stood before Governors-General and high officials, and in doing so he had very worthily upheld the prestige and enhanced the reputation of The Institution.

By some research with the Secretary's secretary, Sir Gordon told us, he had discovered that Mr. Goldup had, in The Institution's interests, eaten during his year of office no fewer than 163 dinners and lunches. He pointed out that, although this might be thought to have helped the Goldup housekeeping, in fact the high laundry bill had to be considered, not that Presidents of The Institution were necessarily untidy eaters.

Mr. Goldup inducts Mr. Goodall into the Presidential Chair

That domestic touch brought him to Mrs. Goldup. She had not been able to accompany the President on his world tour, but she had been there in New York to meet him and to encourage him on the last lap of the journey. The people who had been brought into touch with her during the past year had been greatly impressed by her courage and determination sometimes to set aside ill-health in order that she might stand by the President, and by her graciousness and kindliness when she had been present.

It gave him very great pleasure indeed to propose 'That the best thanks of The Institution be accorded to Mr. T. E. Goldup for the very able manner in which he has filled the office of President during the past year'.

Sir Willis Jackson seconded the vote of thanks to Mr. Goldup in sincere and able fashion. Mr. Goldup could, he thought, worthily be called Professor of Electrical Engineering in the university of industry or, possibly better, Professor of Human Relations, on the grounds that the human problems which were encountered in the practice of electrical engineering, and to which he brought such patience, skill and resource, were, on the whole, rather more troublesome than most of the scientific and technical ones. His contributions to technical education in The Institution and in the profession had been very considerable.

During Mr. Goldup's Vice-Presidential apprenticeship he had been Chairman of the Education and Training and Examinations Committees; and he had represented them on the Joint Educational Advisory Committee of the three engineering institutions and on the National Council for Technological Awards. He had extended these responsibilities to the Radio Industry Council, to the Ministry of Supply College of Electronics at Malvern, to other educational advisory committees, and to the governing bodies of more than one technical college. To all this work he had brought enthusiasm and wisdom and great charm and friendliness of character.

The vote of thanks was carried with loud applause, and after the presentation of the Certificate of Presidency by Mr. Goodall to the retiring President there was a delightful and heartfelt valedictory reply by **Mr. Goldup.** He supposed he had been one of the luckiest Presidents, in that he had had a wonderful opportunity of touring the world and of representing The Institution in many parts and of meeting many members oversea.

As he looked round that crowded Lecture Theatre, he saw many faces that he had come to know and to love. He saw in one corner Mr. Smyth from India, and he was reminded of that wonderful evening they had spent in Bombay, on the ground of the India Cricket Club, where Mr. and Mrs. Brasher and himself and other members of The Institution had had such a delightful time.

He had visited as many of the Centres and Sub-Centres as possible. His wife and he had been extremely touched by the kindness of everyone when they had attended the various functions.

Sir George Nelson, when he had been in that position two years before, had said something like this: 'I was always in the right place at the right time and in the right dress.' He had been referring to the help of his wife in that connection. He had to say, with Sir George, that he had enjoyed the fact that his wife had seen to it that he had been in the right place at the right time and in the right dress. That was a great feat.

As he went out of the Presidential office, Viscount Falmouth was giving up the Honorary Treasurership; during his year of office he had much appreciated his help and guidance in the intricate things that occurred in regard to the finances of The Institution. He had enjoyed their collaboration, and he wished Lord Falmouth in his retirement from the office he had held every blessing and all the health he needed. Might they one day see him back among them perhaps doing a similar task for them again, because, as he knew, the Honorary Treasurership was held for three years.

The President then closed the meeting.

International Special Committee on Radio Interference

ABOUT 80 delegates from 16 countries attended the recent meeting in The Hague of the International Special Committee on Radio Interference (known as C.I.S.P.R.). The committee work under the aegis of the International Electrotechnical Commission, and the British Standards Institution functions as their secretariat. Several international organizations concerned in the suppression of radio interference are represented on the committee.

The meeting (from the 18th to 21st November 1958) was opened in the Palace of Peace, where Prof. G. de Zoeten, President of the Netherlands Electrotechnical Committee, the hosts of the C.I.S.P.R. on this occasion, welcomed the delegates. The C.I.S.P.R. then met in plenary session under the chairmanship of Mr. O. W. Humphreys (United Kingdom).

The work proceeded in three sub-committees which dealt respectively with these subjects: fixing limits for tolerable interference; the technique of measuring interference; and questions of safety arising from the use of suppressor components in electrical equipment.

Interference emanating from high-frequency industrial, scientific and medical equipment is particularly difficult to suppress, since such equipments are specifically designed to generate r.f. energy. Good progress was made, however, towards fixing limits for the interference caused by this class of equipment and towards defining the special measurement techniques involved. Interference caused by overhead transmission lines was also discussed.

The next plenary session will be held in 1961; meanwhile a number of working groups have been set up to study specific problems.

TRENDS IN POST OFFICE TELEPHONE-EXCHANGE EQUIPMENT 621.395.341

The automatic telephone system in this country is well established and widely known. It has continued to evolve, taking advantage of new techniques as they become available to widen the scope of the system, improve efficiency and reduce operating costs. Since 1945, developments in electronic devices and circuit techniques have given a new impetus to progress. On the 5th December 1958 the Queen opened a subscriber-trunk-dialling system at Bristol exchange, the most recently completed development. In this article the author, who is in the Post Office Engineering Department, discusses the influence of electronics on automatic switching equipment, describing such developments as the Bristol s.t.d. system, magnetic-drum directors, and all-electronic exchanges. Subscriber trunk dialling is, however, treated exclusively in a paper (2795 R) with that title, by Mr. D. A. Barron, which will be read on the 22nd January at Savoy Place and will be republished in the Proceedings. A synopsis of Mr. Barron's paper was published in the November Journal, p. 620, and a short review will appear in a future issue.

J. A. LAWRENCE, ASSOCIATE MEMBER

In this country, conversion to automatic working in the telephone network began during the 1920's, and 30 years later it is still incomplete. At no time has the system ceased to develop. New facilities have been added, dialling ranges have been extended, and the search for cheaper and more efficient apparatus continues.

The present system is essentially electro-mechanical; connections are set up automatically over circuits established through chains of switch and relay contacts. Control of connection, in both setting up and clearing, depends on relays, the controlling circuits receiving their setting-up instructions from dial signals.

The serviceability of modern electro-mechanical switching equipment, properly maintained, is better than 98%. Nevertheless, research and development proceed, and already there are clear indications that it may be practicable in the near future to achieve, with electronic components, a comparable performance entirely without mechanical aids.

Later, as design and manufacturing techniques improve, electronic exchanges should be able to compete economically with their electro-mechanical counterparts and should, in addition, be able to achieve lower operating costs.

Recent developments

While the design of an all-electronic switching system is the principal objective of current research, the existence of electronic devices has affected the trend of development of electro-mechanical systems, chiefly in aids to routing, charging control and accounting. Certain of these developments, discussed later, illustrate the influence of electronics on current work in the switching field.

Developments in telecommunication practice since the recent war have not, of course, been confined to switching systems, nor indeed to applications of electronic techniques. There have been developments, for example, in the design of transmission systems, both in reducing costs and in transistorization. The first transatlantic telephone cable has been successfully introduced, and automatic trunk dialling by subscribers (s.t.d.) has been fully engineered, the first installation having been opened for service in December 1958 at Bristol.

GROUP ROUTING AND CHARGING EQUIPMENT

Among specific developments in switching practice the group routing and charging equipment (Grace) which is included in the Bristol s.t.d. installation is of special interest.

In planning a subscriber trunk dialling system for this country, a first requirement is that every subscriber shall have a 'national' number, consisting of his 'local' number, prefixed by a national code number which specifies the location of the exchange to which the subscriber is connected. The national number for each subscriber must be unique and usable without modification from any part of the country.

The routing and charge for a call to any given national number will, however, depend on the call's point of origin, and means are required for translating the number dialled by a caller into the most appropriate routing and the correct charge for each of the possible points of origin (i.e. exchanges), which approach 6000 and serve nearly five million lines. Grace provides the necessary facilities.

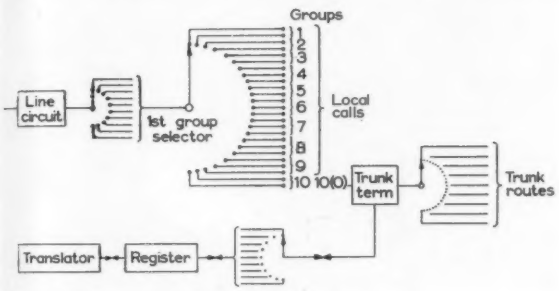
Grouping of exchanges

The 6000 exchanges are subdivided geographically into about 600 groups, each with its own switching centre which provides a common point through which trunk traffic to and from other groups may be routed.

The distance between any two groups also determines the basic charging rate for calls between the groups concerned, so that, although a caller may dial a number connected to any of the 6000 exchanges, Grace need only identify the group within which the wanted exchange is located.

This immediately fixes the basic charging rate and gives enough routing information to permit the call to be advanced as far as the wanted group switching centre, after which the call may, if necessary, be handed over to local routing equipment for completion within the group network.

It is economical to provide at each group switching centre and at some of the larger local exchanges a common pool of routing and charging equipment, which is switched into circuit only when a demand for a trunk call is recognized and switched out again as soon as the wanted connection has been set up. Fig. 1 shows a typical switching arrangement.



1 *Routing of subscriber-dialled trunk call*

Group selection

A caller on lifting his handset is connected automatically to a selector switch, which is arranged to respond only to the first digit dialled. This switch, known as a group selector, provides access to any one of ten separate groups of outgoing circuits and is able to search automatically through any selected group for a free circuit over which the call may be extended to the next and subsequent stages of selection.

Each of the ten groups of circuits corresponds to one of the ten numerals on the dial. Groups 1–9 provide means for directing calls to destinations within the local network via further stages of selection; group 10 is connected only to trunk routes.

Each trunk route is terminated by a control unit known as an outgoing trunk relay set, which provides access not only to the trunk routes but also, via an auxiliary switch, to the group routing and charging equipment. Thus, when a caller dials the digit '0' as a first digit, he is connected automatically to a trunk relay set, and via this to the common pool of routing and charging equipment. He is not permitted to dial over the trunk routes themselves.

Common pool

The common equipment is divided into a register section, containing several registers to allow for calls overlapping in time, and a translator section, which is common to the registers and operates 'one call at a time', its speed of operation being many times greater than that at which calls can be dialled into the registers.

Registering and translation

All digits dialled after the first digit '0' are stored in a register. In general, the first three digits dialled are sufficient to identify the group within which the wanted exchange is located, and as soon as the register has stored these it applies to the translator for a translation of these digits into charge-rate and routing information.

The charge-rate instruction then sets charging equipment located in the trunk relay set to the correct repetition frequency (i.e. one unit of charge for every n seconds of conversation, with n depending on distance), and the routing information positions the trunk selectors, which follow the trunk relay set, to direct the call to the next switching centre in the desired direction.

Meanwhile, additional digits are being received by the register, where they are stored until the route and charge have been selected. They are then repeated forward over the trunk circuit to the next switching centre, where they are either used to complete the call, via local selectors, or, if further through switching is needed, passed via another register–translator unit for further translation, this time for routing only.

Loading of registers and translators

The number of registers provided in any switching centre is related to the number of trunk calls handled by the centre. The time required to receive and set up a call averages about 20–25 sec per call or, say, 150 calls per register per hour if fully loaded. It is not practicable, however, to load each register fully all the time because of random fluctuations in the intensity of traffic, and a practical average loading is about 66% or, say, 100 calls per register per hour during the busiest hours of the day.

A loading of this order, while by no means excessive in modern telephone systems, presents special design and maintenance problems if the quality of service is not to suffer. Moreover, when, for reasons of economy in apparatus, the translating function is made common to a number of registers, the design of the translator can become critical, since it is required to deal at high speed with every call passed through the group of registers with which the common translator is associated.

The limit to the number of registers that can be coupled to a single translator depends on the apparatus used; with wholly electro-mechanical apparatus the limit is low—not more than 15 registers per translator. Electronic apparatus raises the limit considerably: using cold-cathode gas tubes the number of registers per translator can be increased to 40 without difficulty, with the possibility of further increases in the future.

Apart from considerations of speed, it has been found from experience that well designed electronic equipment using cold-cathode gas tubes as the basic electronic elements can be very reliable in operation and have a useful life which appears to be very long (i.e. better than 20 years).

Cold-cathode gas triodes

The group routing and charging equipment used in the Bristol s.t.d. system is wholly electronic, the design being based on cold-cathode gas triodes. The properties of such tubes are particularly suited to the solution of circuit problems such as are encountered in the construction of register–translator units. Fig. 2 shows a cold-cathode register at Bristol exchange.

A gas triode has two stable states: it is either truly open-circuit between anode and cathode, or conducting. Once made conducting, by means of the third (trigger) electrode, it remains so, independent of trigger control, until the potential between anode and cathode is reduced below a critical maintaining value. The current flowing in the anode–cathode circuit depends only on the circuit constants and can be many times greater than that in the trigger–cathode circuit. Triggering is fast (50–100 microsec is typical) and recovery to open-circuit moderately fast (1–3 millisec).

A device with such characteristics can be used in a variety of circuit arrangements. A commonly used element is, for example, a 'gate' capable of permitting or barring the passage of a signal from one part of a circuit to another, depending on the presence or absence of an enabling condition from some other circuit-element or an outside circuit. A cold-cathode gas triode readily fulfils this requirement, because, in the absence of a supply voltage between anode and cathode, the use of the trigger–cathode gap is ineffective in causing anode–cathode conduction, and the anode–cathode circuit cannot pass a signal along to subsequent elements.

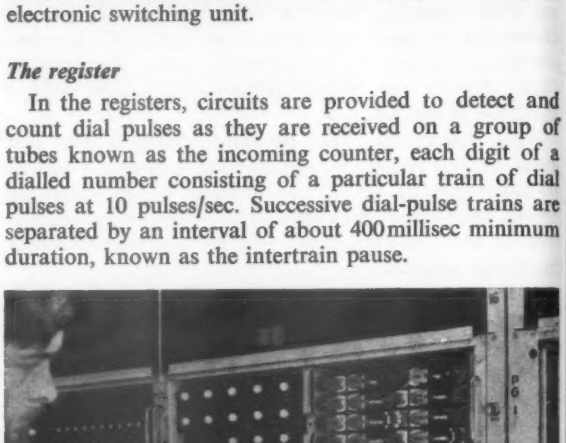
Again, because the trigger–cathode gap will not conduct until the voltage across it exceeds a critical trigger–cathode breakdown voltage, it is possible to combine several inputs to a trigger–cathode circuit via diodes in such a way that until 'all' are present the voltage cannot rise to triggering level. (This corresponds to an 'and' gate having n inputs.) A rearrangement of the diodes readily permits any one of the inputs to cause triggering to produce the equivalent of an 'or' gate having n inputs.

A tube once made conducting across the anode–cathode gap can be returned to its open-circuit state by reducing the anode–cathode voltage below the conduction value. This provides a versatile method of extending the range of possible circuit arrangements and hence the usefulness of the tube as a basic circuit-element.

In the Bristol equipment, gas triodes are used to count dial pulses, store the numerical values of the digits dialled, link counters and stores with control circuits, and so on—in effect to provide all the circuit-elements needed in constructing a complex electronic switching unit.

The register

In the registers, circuits are provided to detect and count dial pulses as they are received on a group of tubes known as the incoming counter, each digit of a dialled number consisting of a particular train of dial pulses at 10 pulses/sec. Successive dial-pulse trains are separated by an interval of about 400 millisec minimum duration, known as the intertrain pause.



2 *A typical cold-cathode register unit at Bristol exchange*

Electronic timers in the register observe the duration of each pulse period and by recognizing the intertrain-pause period are able, during this period, to direct successive trains of pulses from the incoming counter to the appropriate number stores (nine in all) and reset the incoming counter ready for the next pulse train.

Each register is equipped with a programme-control circuit, which keeps track of progress on the incoming side and, later, on the outgoing side. Thus, as dial-pulse trains are received and stored, the register programme circuit notes progress until sufficient pulse trains have been received—say three—and then, from its built-in instructions, causes the register to apply to the common translator for setting-up instructions.

Setting-up instructions

These instructions are received in the form of signals representing pulse trains, which can readily be converted into actual outgoing pulse trains for setting up both trunk selectors and charging stores in the trunk terminating equipment. The setting-up signals are stored initially in the register on an outgoing counter, which, under the control of the programme circuit, proceeds to control the transmission of pulse signals to the trunk relay set (again at 10 pulses/sec) by 'counting down' until the outgoing counter has no more pulses stored.

Setting-up instructions usually contain two or more pulse trains, which are obtained from the translator one at a time, the register making repeated applications to the translator at intervals of about 1·5sec, under the control of the register programme-control circuit, until a signal indicating 'end of translation' is received.

Outgoing pulse trains are, like the incoming ones, separated by intertrain pauses to provide time for the electro-mechanical equipment controlled by the register to operate correctly.

The response of the translator to a request for instructions is so rapid that the problem of ensuring exclusive interconnection between a register and the common translator is reduced to that of allotting the translator to each register cyclically, whether or not instructions are needed. As already indicated, in its present form up to 40 registers can be served by one common translator.

The translator

Internally the translator has a very simple structure. The digits to be translated are transferred (non-destructively) from the register to the translator. Inside the translator they are converted by matrices of cold-cathode tubes into a unique code marking (potentially one out of a thousand for a 3-digit system), which corresponds with a particular charge and route. The code marking actuates a route-and-charge tube which then returns the desired instructions to the register.

Each route-and-charge tube controls several instructions which must be used in the right order. These are obeyed by the registers one instruction at a time, and means for remembering progress in setting up a call are essential. This is done quite simply by an electronic sequence counter located in each register; as the setting-up of a call proceeds, each step advances the sequence counter, and each time an application is made by a register to the translator for the 'next' instruction, the progress counter informs the translator of the numerical order of the next instruction needed.

Security against breakdown and provision for continued operation during maintenance offer special problems when common equipment is used on the scale of the s.t.d. system at Bristol. The equipment therefore contains self-checking elements, which, on detecting a failure, however rare, bring a reserve equipment into service almost instantaneously.

Translation memory system

A special problem is that of providing a translation memory system which is 'permanent' in the sense that continued use does not affect the translation data stored in the memory, yet is flexible enough for translation data to be readily altered by simple operations without interruption of normal working.

In the Bristol equipment the translation data are stored in the translator by wire straps interconnecting electronic elements. The principle is simple yet readily expansible to cover quite large blocks of data.

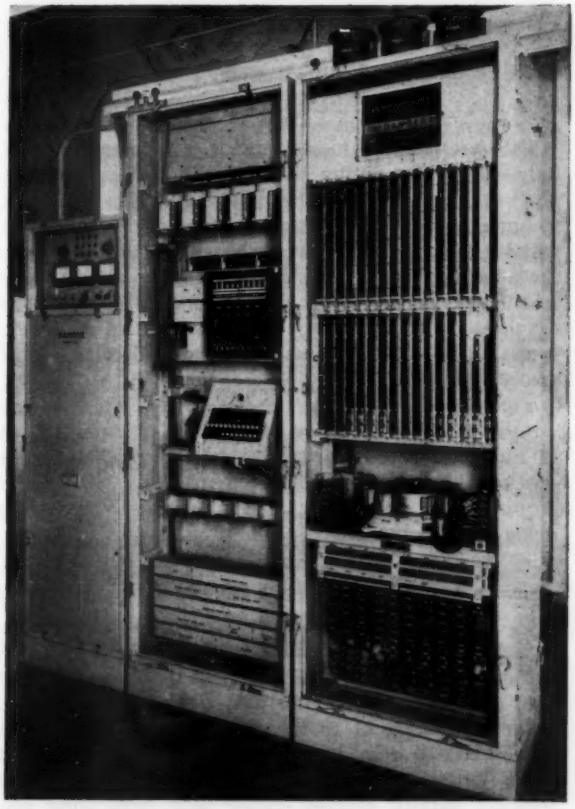
Thus, suppose it is desired to convert the code 23 into a route instruction indicating route 6. The two digits of the code are presented to a 100-point matrix (10 × 10) in such a way that only point 23 is active. Point 23 is connected by means of a wire strap to route element 6, so that whenever code 23 is offered to the matrix the result is always route 6.

Clearly this satisfies the requirement of permanence, yet modification to some other route instruction is easily effected by altering the interconnecting wire strap. To avoid interfering with working equipment a reserve translator is provided.

MAGNETIC-DRUM DIRECTOR EQUIPMENT

The use of register-translator units for control of routing is a principle of general application in automatic switching systems. The idea is not new: it was first introduced in this country in 1926 when the first automatic exchange in London was opened for service.

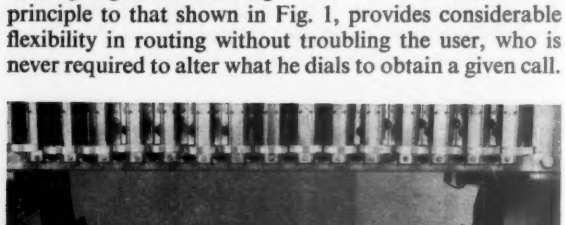
Automatic service in London began with, and continues to use, letter codes for indicating the name of the wanted exchange (e.g. CEN for Central). The same code is used no matter where a call originates within the London Area, and a device is needed to translate the letter codes into routing instructions. Until recently this



3 *General view of electronic director at Lee Green exchange*

has been the task allotted to electro-mechanical register–translator equipments known as directors.

All calls in a director exchange pass via director equipment, which provides the necessary routing instructions. In some instances the three letters of an exchange code are converted into a single routing digit (0–10 pulses); in others there may be up to six successive routing digits. The arrangement, which is identical in principle to that shown in Fig. 1, provides considerable flexibility in routing without troubling the user, who is never required to alter what he dials to obtain a given call.



4 *The drum unit at Lee Green exchange*

The electro-mechanical director equipment is used only during the setting up of a call and is therefore fairly heavily worked. The possibility that electronic techniques might ease the burden on maintenance without affecting service was always present; and, with the advent of the magnetic drum and its allied circuit techniques, an electronic version of the director was developed. The first model of this equipment is already in use in the London Telecommunication Region at Lee Green exchange.

Figs. 3 and 4 show the Lee Green unit, Fig. 4 giving a rather more detailed view of the drum. The unit shown in Fig. 3 has the capacity for controlling all the calls passing through the Lee Green exchange (9700 lines requiring 60 electro-mechanical registers), the drum being 11 in. in diameter and 3 in. deep.

Drum storage

Fundamentally the drum is used only as a storage device. Its surface is thinly coated with nickel which can be magnetized, and the drum can in fact be regarded as a loop of magnetic tape, 3 in. wide and about 33 in. long. The storage of a single element of data requires a space about 0·01 in. long and 0·1 in. wide, so that the drum height may be subdivided to provide many separate parallel storage tracks each 33 in. long and about 0·1 in. apart.

The drum at Lee Green exchange provides up to 30 tracks, each capable of storing about 3300 separate items of data. Each item of data is two-valued (binary), i.e. it may be recorded in one of two ways—either in the same sense as the direction of rotation or in the opposite sense; it is merely a matter of controlling the direction of a current pulse in a recording head. Conventionally one direction of current is given the binary value '1' and the other the value '0'.

The method of using the drum is of particular interest, since it not only provides a basic memory capacity for 648 sets of routing instructions but also uses some of the tracks for control of circuit operation.

Addition

For example, when a train of pulses representing a dialled digit is being received, it is necessary to count the number of pulses in the train. Counting is, basically, a process of recognizing the arrival of each successive pulse and adding it to the total of pulses already received.

Using binary arithmetic, addition by unity is particularly easy. To record up to ten in decimal notation four binary digits are required, so that if, say, three pulses have already been received the record would be 1100 (with the least-significant digit on the left). The addition of a fourth pulse would alter the record to 0010. In effect the rule for adding unity is: change all 1's to 0 until the first 0 is reached, change this to 1 and stop.

If the record is on the drum the associated electronic circuit need consist only of the usual reading- and writing-head circuits, a pulse detector, a start/stop adding element and a digit-reversing element. In operation the drum record is played back via the reading-head circuit to the associated circuit every $16\frac{2}{3}$ millisec.

Nothing happens unless the pulse detector registers a new pulse, when the start adding element sets the reversing element into operation to alter each 1 on the record to 0 until the first 0 is reached. The 0 is changed to 1 and the playback of the 0 record resets the adding element to stop any further change in the record until the next pulse is detected.

By methods such as this considerable economies in equipment are possible because the electronic circuit-elements can be time-shared over many similar input/output circuits. The playback time of $16\frac{2}{3}$ millisec is a function of the time required just to detect a single dial pulse, which in the worst case may last only 18 millisec. The over-all result is to produce a circuit operating at about 100 kc/s.

Physically the register and the translator are combined, although in circuit operation the translator is a separate unit, similar to that shown in Fig. 1. Thirteen of the 30 possible tracks are used for register digit storage and circuit control; ten are used for the routing-instruction memory. The use of tracks for circuit control as well as storage represents a departure from the usual practice of using a magnetic drum merely as a large-capacity memory.

Register input/output circuits

Interworking with the existing electro-mechanical equipment is provided via register input/output units containing a few relays and a number of electronic toggle circuits. The input/output circuits are scanned at a rate of 60 scans/sec, which is fast enough to ensure that the most rapid change in the state of an input or output (e.g. the beginning or end of a dial-pulse signal) can be recognized and recorded on the drum.

Each input/output circuit is allotted its own set of storage elements (bits) on a register track, and the associated scanner is synchronized with the drum circuits. Thus the state of each input/output circuit is kept continuously under review on the register tracks, and, by comparing every change of state in any external circuit with a programme unit built-in to the drum circuits, the appropriate action can be taken—digits can be stored, timed, translated, transmitted, erased and so on according to the requirements.

An important difference between the magnetic-drum equipment and the Bristol s.t.d. equipment is that the routing instruction memory on the drum is electronically recorded and, as necessary, electronically amended.

Compared with existing electro-mechanical registers the saving in accommodation is almost 75%. There are good prospects that, in production, the drum unit could compete economically with existing electro-mechanical equipment. The present equipment is based on the use of hot-cathode valves in the control circuits: transistorization is the next step.

THE ALL-ELECTRONIC EXCHANGE

The developments so far described, although important in their own right as contributions to the design of existing types of exchange, are also important as preludes to the ultimate production of an all-electronic exchange. Their use in public service has established beyond question the potential importance of electronic techniques in the future development of switching systems; operating and maintenance experience has been gained; and the high degree of reliability obtainable with conservatively designed electronic equipment is no longer a matter of conjecture.

If the design of an exchange were merely a matter of providing the means for setting up and releasing connections, the all-electronic exchange might well be said to be already achievable. Speech over established connections must, however, reach certain standards of quality, freedom from crosstalk and noise; and much attention is being given to methods of meeting these requirements.

Broadly speaking, the speech paths through an electronic exchange may be established either in the form of interconnected matrices of electronic 'crosspoints', such as gas tubes or transistors (space division), or in the form of interconnected time-division-multiplex units.

Space division

In space-division systems the transmission problems tend to be simpler than in t.d.m. systems because the electronic crosspoints act primarily as 'contacts'; but it is not yet clear whether or not an electronic space-division system can compete economically with a t.d.m. system over a sufficiently wide range of exchange capacities.

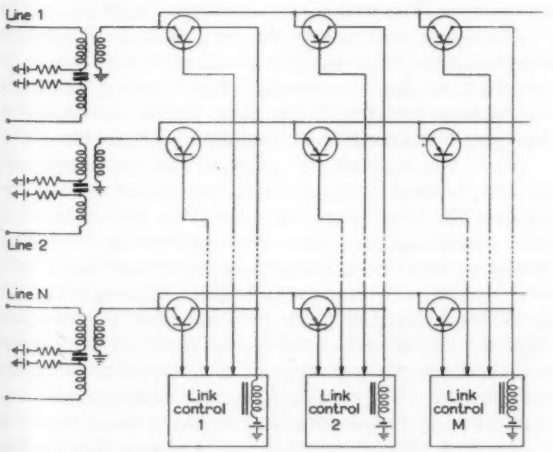
Electronic space-division systems tend to follow the patterns of interconnection found in electro-mechanical systems, where each possible path through the connection arrays has a separate physical existence. Arrays can, however, be built up from elementary electronic devices in any desired manner without reference to mechanical arrangement; moreover, the inherently fast operation of electronic devices permits the construction of highly efficient patterns of interconnection, in which calls can be offered to the whole array 'one at a time' without causing delays.

The paths available to a call need not therefore be influenced by restrictions common in electro-mechanical systems owing to the mechanical arrangement of the switches and the need to offset their relatively slow operating characteristics by permitting many calls to be set up more or less simultaneously.

Fig. 5 illustrates a much simplified electronic switching unit based on transistor crosspoints. Any of the N lines can be connected to any other of the N lines over any of M links, M being much smaller than N and depending on the average number of simultaneous calls.

Practical systems often have several similar arrays suitably interconnected, and the basic design problem is that of devising an interconnection pattern that gives a minimum number of electronic interconnecting elements (crosspoints) per line for a given number of calls per line per hour. In electronic space-division systems so far proposed, the number of crosspoints per line appears to lie between 15 and 25.

The transistors shown in Fig. 5 act merely as



5 *Simplified electronic switching unit using transistor crosspoints*

low-resistance contacts in the 'on' condition and substantially as open-circuits in the 'off' condition. Each transistor needs to be associated with a memory unit arranged to maintain any selected pair of transistors on any selected link in the 'on' condition for so long as the link is in use.

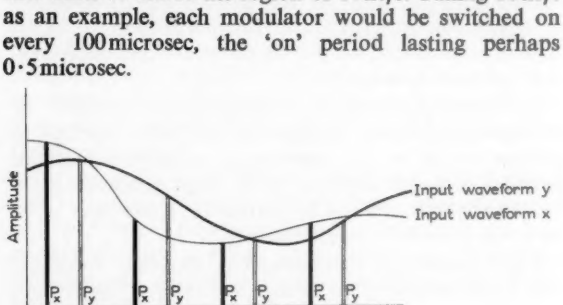
Other types of crosspoint having inherent memory features, such as gas tubes or *p-n-p-n* diodes, which have advantages either technically or economically, could be used; the best arrangement still remains to be determined. Its ultimate form will be determined by the over-all economics of the system.

Time-division multiplex

Time-division multiplex systems avoid the problem of constructing economic arrays of electronic crosspoints, but means must be provided for converting the audio waveforms present on a number of spatially separate lines into modulated pulse trains distributed timewise on a physical path common to all the lines concerned. Once the conversion has been effected the problem of interconnecting any two lines can be reduced to that of allotting the appropriate control pulses to the modulators of the two lines concerned.

The principle of the continuous- to pulse-waveform conversion is simple. Each of the waveforms to be time-multiplexed is connected via a pulse modulator to a common physical path known as a highway. Each modulator is switched on for a short period by a modulator control pulse at a regular rate which is at least twice the highest audio frequency to be transmitted.

At the present time there appears to be no compelling reason for providing an audio bandwidth exceeding 4kc/s (e.g. 0·3–4·3kc/s), so that the pulse-repetition rate tends to fall in the region of 10kc/s. Taking 10kc/s as an example, each modulator would be switched on every 100microsec, the 'on' period lasting perhaps 0·5microsec.



6 ***Principle of waveform conversion***
t = Pulse-repetition interval

The several waveforms to be multiplexed are each allotted a different modulator control pulse, so that on the common highway the combined pulse pattern is a sequence of half-microsecond pulses repeated every 100microsec. If each modulator control pulse were allotted a time interval of 1microsec, 100 different audio waveforms could be multiplexed timewise, without mutual interference, on a single highway.

One of the simplest (yet most effective) ways of causing a modulator control pulse to carry the intelligence contained in an audio waveform is to arrange that the amplitude of the modulator pulse, after it has passed through the modulator, shall be proportional to the amplitude of the audio waveforms at the instant the modulator control pulse is applied. Since the modulator control pulses recur every 100microsec, the changes in the amplitude of successive pulses in the resulting pulse train follow the corresponding changes in the audio waveform for all frequencies up to 5kc/s. Fig. 6 illustrates the principle of conversion applied to two possible waveforms.

The reverse process, by which the pulse waveforms on the highway are returned to continuous audio waveforms, consists in gating the highway pulses appropriate to a particular channel into a low-pass filter, which removes the pulse-repetition frequency and integrates the pulse waveform. If necessary, power losses in modulation and demodulation are made up by one amplifier per line following the low-pass filter.

Once the pulse waveform is established on the highway, interconnection between any two lines on the same highway is, basically, merely a matter of allotting the same modulator control pulse to the modulators of both lines and, once the allocation is made, of maintaining the allocation while the call lasts. In practice this rather simple arrangement possesses certain disadvantages, and slightly more complicated relationships exist between the pulses allotted to a connection; but the principle described is sufficient to illustrate the basic difference between t.d.m. and space-division systems.

A complete t.d.m. unit is, in effect, a connecting unit providing N independent channels, where N is the number of separate modulation control pulses available within the pulse-repetition interval. By providing means for allotting modulation control pulses to modulators, a single 100-channel t.d.m. unit can easily serve up to 800 lines. Units may be arranged for both-way transmission over a single physical path (two-wire), or may have a separate physical path for each direction of transmission (four-wire). The precise arrangement depends on the method of modulation employed.

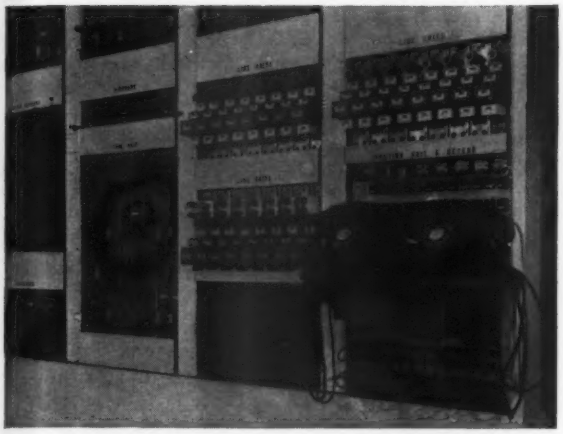
When the number of lines to be interconnected exceeds the capacity of a single t.d.m. unit, means are required for interconnecting units. Two possibilities are open. The original audio waveform can be recovered from one highway by demodulation and the recovered waveform used as an input to another highway. Alternatively, each highway may be connected to all other highways by pulse-operated gates, which, if opened by modulator control pulses at the appropriate times, provide means for routing the pulse trains on any one highway to corresponding time positions on any other.

The first method appears to be more suitable for small-capacity systems using only a few highways. The second appears to be more economical for systems with

many highways. A full evaluation of the alternative techniques is still incomplete.

Practical t.d.m. systems

Several practical t.d.m. systems have already been designed and constructed in various laboratories. At the Post Office Research Station at Dollis Hill a four-wire t.d.m. system operated as a private automatic exchange for some considerable time with successful results.



7 *An experimental t.d.m. electronic-exchange unit*

Typical of other work in this field is an experimental t.d.m. unit, part of which is shown in Fig. 7. Similar projects, in both space and time-division fields, have demonstrated the practicability of electronic switching.

Future developments

In the present state of development of all-electronic exchanges at least one practical solution has been found to each of the many problems encountered. The British Post Office is already collaborating with the principal manufacturers of exchange equipment in this country in the construction of an experimental all-electronic exchange for public service at Highgate Wood in the London Area. This exchange should be able to carry live traffic by the middle or end of 1960.

Work is also proceeding on more-advanced studies of exchange-design problems, and there seems little doubt that an all-electronic system capable of competing with existing electro-mechanical designs can be achieved within a reasonable time.

Meanwhile the introduction of electronic switching techniques into the present electro-mechanical system continues to receive close attention. It appears that electronic register–translator units may soon be economically competitive with their electro-mechanical counterparts.

Automatic accounting is another field in which electronic techniques will play an important part: in fact, a model of an automatic call-charge recorder, based on the magnetic drum, should soon be on trial.

This will not be used initially at Bristol, since it is still experimental and needs to be evaluated both operationally and economically before development for production is undertaken.

Summary

The development of the telephone service in this country is a continuous process, and an important part of the effort available in the Post Office Engineering Department is devoted to scientific and development studies covering a wide range of subjects in the field of telecommunication.

Inevitably the growth of the electronics industry is affecting the trend of development of telephone-exchange equipment, both in exchanges of existing type, where electronic devices are being used as aids to a widening of the range of facilities offered, and for new exchanges as a means of replacing electro-mechanical switching equipment entirely.

Much of the circuit technique required for an all-electronic exchange is already well established—the next step is to develop highly reliable apparatus which can be produced economically in quantity.

Electronic aids to switching control are already in public service; subscriber trunk dialling opened at Bristol in December 1958 using an electronic routing and charging equipment (Grace); and the first all-electronic exchange in this country intended for public service is in an advanced state of development and should be ready to carry live traffic by the autumn of 1960.

Direct dialling from the Continent

OPERATORS in certain European exchanges can now dial direct to subscribers in London and a number of provincial exchanges. The opening, in November 1958, of a new automatic exchange in the Continental Exchange, London, means that a London operator is no longer needed to help in setting up these calls.

The new method, perfected after several years' trial, will give greater speed and efficiency in handling traffic between this country and the rest of Europe. Other European countries are installing similar equipment so that Continental Exchange operators can dial direct to their subscribers.

Use is being progressively extended by international agreement, and by 1961 most of the calls between Europe and the United Kingdom will be connected without the intervention of an operator in the called subscriber's country.

Many European operators speak English. But if language difficulties are experienced, occasionally a London operator can be called into the circuit, by the European operator, to help.

The four pillars of The Institution

4 THE UTILIZATION SECTION

Final instalment of a series describing the life and work of the specialized Sections

THE Utilization Section, the newest pillar of the four, was born in 1941, in time of war, as the Installations Section. It takes the whole field of the practical utilization of electrical energy for its province, save the special fields of radio and telecommunication. Its 4700 members are directly engaged in helping others achieve a better application of electricity to the whole range of tasks of which it is capable. The biggest users are certainly their fellow electrical engineers.

A war-time founding

The founding of the Section in July 1941 was largely due to the enthusiasm of Mr. H. T. Young (President, 1936), who served as the first Chairman of the Section and is rightly dubbed its 'father'. The establishment of this new Section had been under consideration some time before the outbreak of the recent war; but action had been postponed, perhaps because of the financial burden on the revenues of The Institution as a whole which the setting up of a new specialized Section involves.

Be that as it may, the climate of opinion soon changed in favour of its establishment. Although the background of life for electrical engineers and others in this country became increasingly grim as the war continued, the Council were in no doubt of the eventual outcome and early turned their attention to planning for the post-war period.

In sympathy with the public mood which found expression in debates in Parliament in the early months of 1941, the Council set up a representative post-war planning committee, which appointed a number of sub-committees to deal with such specialized problems as education, training, research, electricity supply, installations, telecommunication, production and standardization.

In retrospect, some may discern an element of escapism or wishful thinking in these activities, but, as is well known, they bore considerable fruit, not least in the field of utilization. One of the first steps taken by the newly formed post-war planning committee was to revive the proposal for an Installations Section and to recommend to the Council that it should be formed without delay. The committee realized not only that post-war problems in the utilization field called for special study but that there were urgent war-time problems needing immediate attention. The pattern of this approach may be clearly appreciated in the programmes of the early meetings held by the new Section.

At the first meeting of the Installations Section the then President, Mr. J. R. Beard, presided, the Section Chairman, Mr. H. T. Young, being unfortunately indisposed. A paper by the late Mr. R. Grierson was read and discussed, its title being 'Space heating by means of electrically warmed floors, with special reference to surface-type air-raid shelters'.

In quick succession there were papers on the rationalization of colliery electrical equipment and on problems in the application of electric heating to residential and commercial premises, and informal discussions on electrical-installation problems in war factories and on the war-time maintenance of electrical installations and equipment. A paper by Mr. Forbes Jackson and Mr. E. E. Jacobi, read in March 1943, indicated the shape of things to come: it was called 'The future of the domestic wiring installation'.

Electricity in buildings

One important aspect of the Section's interest was reflected in the work of the electrical installations committee, convened by the Council in June 1942 in response to an invitation from Lord Portal, then Minister of Works. This was part of a scheme, inaugurated by Lord Reith when he was Minister of Works and Planning, 'with the object of securing a comprehensive and co-ordinated review of building technique for the guidance of those who would be responsible for the direction and organization of building after the war'.

The committee's report was adopted by the Minister and published by the Stationery Office in 1944 as No. 11—Electrical installations—in the series of post-war building studies. Its contents ranged over the whole field of the safe and convenient use of electricity in buildings. It well repays rereading now.

The recommendation by which it will be best remembered is no doubt that for the provision of a ring circuit to afford an economical means of supplying a substantial number of socket-outlets giving supplies to appliances through an associated fused plug. The suggestion was a sound one and met a real want. This and other suggestions first made in the report, e.g. for a compact consumer's-supply control unit, have borne fruit and been widely adopted.

To enable these and other changes to be taken up in installation practice, alterations were required in the Wiring Regulations of The Institution—the well-known Regulations for the Electrical Equipment of Buildings, to give them their full title. These were duly made and promulgated in 1946. Successive editions of the Regulations have preserved these provisions, each time with some broadening. They are, of course, incorporated in the current, 13th edition.

The close concern of the Utilization Section with the formulation of Wiring Regulations for Buildings can be seen in the fact that its Chairman is, *ex officio*, a member of the Wiring Regulations Committee. It is no mere coincidence that the Chairman of that Committee is himself a Past-Chairman of the Utilization Section and that no fewer than three other Past-Chairmen are members of his Committee.

There is a corresponding relationship with the Ship Wiring Regulations Committee, whose Chairman is a Past-Chairman of the Section. There are close ties with the Committee on Regulations for the Electrical Equipment of Aircraft, on whose recommendations the electrical chapters of the British Civil Airworthiness Requirements are based.

The Section's interest is not confined to regulation-making in these important fields. Its members have given strong support to the activities of the Codes of Practice Council,

through the Codes of Practice Committee for Electrical Engineering, and of the related drafting committees which are concerned with the preparation of codes of good practice in the use of electricity. In these, the recommendations may go beyond the bare requirements of safety; and for this reason they are not expressed in mandatory language but offer guidance based on professional knowledge and experience.

In describing these regulations and code-making activities, we have in fact delineated three important areas of the Utilization Section's interests: let us look a little more closely at each in turn.

Electricity on land

Here, as in the other spheres, the prospect is limitless. The range of activity is constantly widening, corresponding with the all-embracing nature of the *aspects* set out in the Section's official scope: '. . . the installation, operation, application, employment and maintenance of cables, equipment and apparatus used in electrical installations, and the study, design, manufacture and construction of equipment for the utilization of electrical energy.'

As can be imagined, the range of papers read and discussed at Section meetings, bearing on these topics, is wide indeed—a random choice from recent sessions gives this list: Brushless variable-speed induction motors; Electric control of stage and television lighting; Electric lifts in post-war housing; Post-war electrification of the Polish railways; Electrical floor warming; The automatic factory; Electricity in modern commercial horticulture; and so on—there is endless variety.

But the meetings of the Section are not directed solely to discussions between engineers. Valuable missionary work has been done in calling the attention of a wider circle to the potentialities of electrical energy. Thus in November 1950 a two-day Conference on Electricity as an Aid to Productivity was held, at which the opening address was given by Sir Vincent Z. de Ferranti (Past-President). An audience in which industrialists and works managers predominated heard papers by experts on such topics as motive power; industrial heating; welding; the handling and inspection of materials; and the lighting, heating and ventilating of factories.

More recently, in November 1958, there was an all-day Symposium on The Provision of Adequate Electrical Installations in Buildings. This had as its objective the awakening of builders, architects, and public servants generally to the importance of adequate and convenient facilities for the enjoyment of the amenities electricity can bring, in all the building projects for which they are responsible.

Electricity on the high seas

The Section takes within its scope the manifold uses of electricity on shipboard, though not those concerned with radiocommunication and radionavigation, which fall within the province of the Radio and Telecommunication Section. In the nature of things, papers on electricity at sea do not preponderate, but the Section's interest in the subject, and responsibility for it, are undoubted.

A Past-Chairman of the Section, as has been noted, is Chairman of the Ship Wiring Rules Committee. He is also the Chairman of the International Electrotechnical Commission Technical Committee No. 18—Electrical Installations in Ships. This committee, through their recently published 'Recommendations' on this subject, have gone far to achieve an internationally agreed approach to the engineering of shipborne electrical installations, on a basis which is recognizably similar to that of The Institution's Regulations for the Electrical Equipment of Ships.

Electricity in the air

Here, the sky is not the limit, as current news of satellites and probes makes clear. In addition to the regulation-making activity which has been described, the Section Committee are taking pioneering action to direct attention to the needs and problems of the most effective and practical utilization of electricity in the air. To this end, they organized, in May 1956, a three-day Convention on Electrical Equipment of Aircraft, opened by the Minister of Supply, at which 19 technical papers were presented and discussed.

The Section Committee are now concentrating on the need for an ever-closer collaboration between the aerodynamicists, the structural experts and the electrical engineers in the over-all design of new aircraft from the earliest stages of a concept, as it is evident that the day is long past when electrical requirements could be met by *ad hoc* additions in the later stages of design or even prototype construction.

Task for vision and enthusiasm

All the foregoing has dealt with the serious preoccupations of the Section, in which importance has always been given to encouraging the participation of the younger members: an evening is regularly set aside each session for the reading of papers from this source. But the Section also has its social side. It arranges visits from time to time to establishments of engineering interest and also holds an annual Dinner-Dance and an annual Summer Visit, usually of two days' duration, in a locality which offers opportunities to see engineering works and, incidentally, places of scenic or historic interest.

As in the case of the other three pillars, the Section's base is not solely in London. Its activities extend to the Western, North-Western, North Midland and South Midland Centres, where there are flourishing Utilization Groups, that of the South Midland Centre being organized jointly with the Supply Section.

Utilization and supply are complementary—with no utilization there would be no supply, and vice versa. The spectacular growth in the output of electricity has been due to the men who developed its use no less than to those who provided the power stations and the transmission and distribution lines.

Utilization offers an interesting and rewarding career. The ways in which electricity has been used, and will be used, are so varied as to cover the whole field of human activity.

A successful utilization man must have an all-round knowledge of electrical engineering so that he can see which particular characteristic of electricity can best be applied to the problem with which he is dealing. It may be heating in one or other of its many forms, it may be lighting, it may be power, or it may be the control of machines. He has got to be so interested in the other man's job that he can see how and where electricity can be put to work. His task requires vision and enthusiasm, tempered by knowledge and judgment.

For such a man, participation in the work of the Utilization Section is of great value, as it keeps in front of him and his colleagues every aspect of the use of electricity and, in the discussions, enables him and them to learn from the successes—and sometimes from the disappointments—of others working in the same field. Mr. H. T. Young did a great service not only to the electrical industry but to the users of electricity when he 'fathered' the Utilization Section.

ADDRESSES OF THE SECTION CHAIRMEN

We present here summaries of the Addresses given by the Chairmen of the specialized Sections at the opening of the current session. A longer abstract of each Address is being published in the January (Part B) issue and/or February (Part A) issue of the Proceedings.

Utilization

Installation engineering

The Address was delivered by the Chairman, ***R. A. Marryat, B.Sc.(Eng.), Member,*** *to members of the Utilization Section on the 16th October 1958. Mr. Marryat is with Marryat and Place Ltd.*

THE design and execution of electrical installation work are the particular concern of the Utilization Section of The Institution, and it is incumbent on its members to ensure that the provision made for distributing electricity in all new buildings is such as will facilitate full and abundant use of electricity and so meet future needs for better living and higher productivity.

It has never been possible to lay down in The Institution's Wiring Regulations what should be regarded as an adequate installation in any particular type or size of building; for this purpose the preparation of a detailed specification is necessary. In such a specification, full account should be taken not only of all immediate requirements, but of the provision to be made for future extensions and development, of experience in other similar installations, and of such guidance as may be available in relevant Codes of Practice.

Irrespective of the intended purpose of any installation, it will generally be necessary to make an advance estimate of earth-loop impedance before design of the main switchboard and distribution boards can proceed. If overload-protection devices are to be used for earth-fault protection, a consumer's earthing terminal directly connected to the neutral point of the supply transformer should be provided. Wherever loads much in excess of 100amp are involved, the installation of a transformer substation on the consumer's premises should be considered.

Where such treatment is impracticable, reliance may have to be placed on the use of earth-leakage trips. The advantages and possible future application of current-balance earth-leakage circuit-breakers are worthy of notice. If limitation of leakage current to 15% of full load, and of voltage increase on exposed metalwork to 40 volts above earth, may be accepted as a criterion of satisfactory protection, differential-current-operated circuit-breakers can be effective when the earth-loop impedance is three times the maximum value acceptable with fuses of the same current rating.

Consumer's control units larger than those specified in B.S. 1454 might well be developed for use in larger houses and small commercial premises, incorporating an h.b.c. service fuse, 150amp differential-current-operated circuit-breaker, and miniature circuit-breakers, with or without voltage-operated leakage trips, for protection of sub-circuit wiring.

Modern trends and standards

Modern trends in internal-distribution practice involve feeder bars and plug-in busbar systems, cable ducts and trunking, cable trays and crimped terminal lugs, and the application of dry-type transformers. I^2R losses must be considered in determining the rating of cables for main distribution. With single-shift working, electric energy at 1d. per kWh, and combined interest and depreciation on capital cost at 15%, it may be quite uneconomical to rate main distribution cables in accordance with Tables given in the Wiring Regulations, based on temperature rise alone.

Regarding progress in standardization of installation materials and equipment, there is a need for dimensional standardization of switch and fuse units in cubicle and unit types of switchboard, fixings of fluorescent-lighting fittings, elements for electric fires, and plugs and sockets for low-voltage supplies. Perhaps 5 and 15amp plugs and sockets to B.S. 546 should no longer be recognized as suitable for new installations in homes and offices etc.

Over-all economy can often be achieved by so planning installations that work on site is reduced to a minimum, as, for example, in the growing use of grouped motor-control panels in industry. Care should be taken to ensure that components in master control panels are clearly marked to indicate their function, and to see that spare parts, fuse cartridges and a key diagram are fitted in the enclosing cubicle. There is an increasing use of remote supervisory control panels, with mimic diagrams indicating the operating condition of plant spread over wide areas, in large industrial projects.

The installation engineer has a vital part to play in the future development of the industry both at home and oversea, and there is now a challenging opportunity for young men of technical and practical ability to build for themselves full and interesting careers that will bring them work of great variety and consequence, and real pride in personal achievement.

The scope of the Measurement and Control Section

The Chairman, J. K. Webb, M.Sc.(Eng.), B.Sc.Tech., Member, delivered the Address to members of the Measurement and Control Section on the 14th October 1958. Mr. Webb is with Standard Telecommunication Laboratories Limited.

THE scope of the Measurement and Control Section has been greatly extended since its early days, following the impact of improved analytical methods, the continuous urge towards ever greater precision in the definition of our standards, and the advent of new materials, nucleonics and improved measuring techniques, computers, data-processing and servomechanisms, which have all added to the complexity of its interests.

In order to illustrate the present scope of the Section, its work may conveniently be divided into five main 'panels'.

Panel 1—Fundamentals, standards and laboratory measurements

As an earnest of our aims and intentions as electrical engineers, it is suggested that the use of the M.K.S. system in the *Proceedings* be made mandatory. By obliging members to take stock of its practical working, this would remove many misconceptions and would also probably have a snowball effect on the attitude of other authorities.

Recent progress in the definition of the primary standards of mass, length and time is noteworthy, besides the ingenious means by which electrical standards are referred to these primary standards. The determination of the farad is particularly interesting. Whereas the farad has always remained a secondary, derived unit, the practical possibility of measuring it directly in terms of length, by a method developed by Thompson, follows the recent publication of a theorem by Lampard.

Panel 2—Materials and components

The development of 'hyper-pure' silicon, used in the manufacture of transistors and certain types of diode, is worthy of attention. Electrical methods are capable of determining impurity levels of the order of 1 part in 10^{12}. The most troublesome contaminant is boron, but a virtually boron-free silicon can be produced by decomposing highly purified gaseous silane (silicon hydride). In this way, it is possible to manufacture on a commercial scale a grade of silicon having a resistivity of over 1000 ohm-cm, with a hole lifetime above 200 microsec for *p*-type material. Now that this material is available, important advances are anticipated.

Panel 3—Measuring techniques, devices and instruments

The scope of this panel makes it possible to discuss a wide variety of subjects: that chosen concerns the new development of solderless wrapped connections as applied to 25 s.w.g. wires. The soldered connection has a number of shortcomings—in particular the menace of the dry joint—and the wrapped connection many advantages. We may distinguish between two types of the latter, termed primary and secondary, or better, wrapped and bound. The bound type has certain advantages when applied to components.

Although proving the new technique has been a major problem, it is being successfully tackled, and a big future is predicted for both wrapped and bound connections.

Panel 4—Data-processing, including analogue and digital computers

There has been extremely rapid development of the digital computer over the past few years, and the efforts of the Section have furthered the solution of the associated engineering problems. By way of example, one facet, that of memory systems, may be discussed. Various devices have been used to store information. Concerning those which have survived, we may note particularly the question of their access time.

Great interest is now being centred on a memory cell based on flux trapped in superconductors by the application of a magnetic force above a certain critical value, since it points the way to the design of a large memory having a cycle time of only 10^{-8} sec. This is now practicable because helium liquefiers or 'cryostats' have become commercially available. In computing machines which can perform a million arithmetical operations per second, such high-speed memories are essential, although there will still be a place for lower-speed devices wherever these prove to be more economical.

Panel 5—Servomechanisms and control systems

The subject of servomechanisms has many ramifications, ranging from servo-operated recording instruments to the automatic control of the position of massive objects. One aspect, the fascinating subject of magnetic levitation in a d.c. field, made possible by servomechanisms, may in time assume practical importance.

A scheme for levitating a mass of iron, which could act as a scale pan and be applied to automatic weighing techniques, illustrates the application of servomechanism principles. The method employed to secure adequate damping is the most notable feature.

Supply

Art, craft and rampart

*The Address was delivered by the Chairman, **D. P. Sayers, B.Sc., Member**, to members of the Supply Section on the 29th October 1958. Mr. Sayers is with the Central Electricity Generating Board.*

THE Supply Section, now entering its 25th year, was originally called the Transmission Section and was a development of the Overhead Lines Association formed in 1927. The Council made an important change in 1948 when the scope of the Section was extended to include generation. It is hoped that this basic branch of the industry will receive increasing attention in the future activities of the Section.

The heavy-current side of electrical engineering does not make the same appeal to the young engineer as electronics, but a broad survey of the field covered by the Supply Section reveals that there are still plenty of exciting developments and problems to satisfy the best brains and the most adventurous spirits.

The first point to be noted is that, notwithstanding all the modern scientific aids such as the computer, engineering achievement still calls for the art and craft of the engineer, and he must make his projects pay as well as make them work. To see the achievements of the past and the possibilities of the future in true perspective we must mount the ramparts and look for the high spots—hence the theme 'Art, craft and rampart'.

The electricity supply industry has had a long record of steady expansion, and the price of the kilowatt-hour to the consumer is less today than it was 20 or 30 years ago, both in terms of money and of real value as measured by the price of other commodities. The average price today of all units sold in England and Wales is almost exactly 1½d., of which generation accounts for two-thirds, distribution for nearly one-third and transmission for the very small balance of some 3%. Most of this Address is devoted to a broad review of developments and current trends in generation, transmission and distribution and their influence on costs.

Present progress—future problems

In the case of thermal generation, on which this country mainly depends, the use of larger generating units with higher steam pressure and temperature has resulted in a reduction in both capital and running costs, leading to an over-all decrease of the order of 25%. British manufacturers are now building a 550MW set which, with its associated boiler, will be larger than any other in the world.

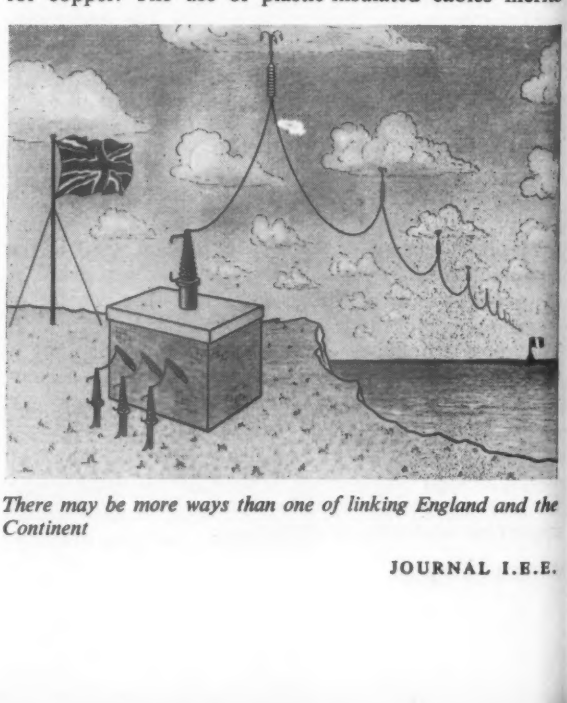
Little water power is available in the British Isles, but the output of the North of Scotland hydro-electric schemes is equivalent to one million tons of coal per year. Much use is made of water power in other parts of the world, including some very large installations under construction in the Soviet Union. The Kariba development in Rhodesia is of special interest to British engineers and epitomizes engineering achievement.

The application of the peaceful use of nuclear energy in the generation of electric power is the most outstanding achievement of the present age and offers unlimited scope to the younger members of The Institution.

In the field of transmission there has been a steady progression towards higher voltages, leading to reduced costs per kilovolt-ampere transmitted; but line insulators remain a serious obstacle in the way of using voltages higher than 300–400kV. Insulated cables are now in service up to 400kV, but their cost is prohibitive for general use. High direct voltage may be more economical in special cases.

Developments in transformer design and manufacture have kept pace with system growth, but further economies in scale are becoming difficult because transport restrictions limit the maximum size of plant. Switchgear developments continue to meet the technical requirements, but the cost of switchgear in the British Grid system appears to be high in relation to that of other items. The coming into operation of substantial sections of the 275kV Grid system opens the way for national economic system operation.

In the field of distribution there is much scope for the engineer's judgment and art in deciding how, when and where to provide for the future. There is need for a closer fit between the planning and design of plant and the constantly varying characteristics of the load to be met. Area Boards have achieved significant economies in labour and materials by mechanization of excavation work and pole erection and by substitution of aluminium for copper. The use of plastic-insulated cables merits



There may be more ways than one of linking England and the Continent

attention. Substantial economies have been achieved in transformers by the use of cold-rolled steel and standard specifications. High-speed reclosers on rural networks are reducing the number of interruptions of supply.

In the heavy-current field the potentialities of the future are no less than the realizations of the past; but problems abound, the solving of which will bestow a real sense of achievement and endow a worthy career.

Radio and Telecommunication

Random thoughts of a propagation engineer

The Chairman, G. Millington, M.A., B.Sc., Member, delivered the Address to members of the Radio and Telecommunication Section on the 22nd October 1958. Mr. Millington is with Marconi's Wireless Telegraph Co. Ltd.

One of the greatest problems facing research workers is the flood of papers that ceaselessly pours from the technical Press. With the rapid advances in technology, it may be inevitable that papers will appear in ever-increasing numbers, but anyone who contemplates writing a paper for publication should ask himself if the information he wishes to impart is likely to be useful to others and to stimulate further advances.

Moreover, greater attention should be paid to the way a paper is written. It is essential that the busy engineer should be able to assess quickly the probable value of a paper, and this should be possible if it is well set out and lucidly written. This need is most acute in the case of papers in which a physical problem is solved by mathematical analysis. The authors of these should consider carefully whether they have expressed their conclusions in the form best suited for their intended application.

There are two special problems which beset referees from time to time. The first concerns the paper that presents some strikingly new material but which is so obscure that no one can understand it. The hapless referee is anxious not to condemn a work of genius, but equally he hesitates to sanction what may prove to be a lot of nonsense. As a general guide, if a paper containing controversial or even revolutionary concepts is written for the benefit of engineers, it should be understandable by the appropriate experts, since, if they cannot follow it, it is unlikely that anyone else will be able to do so.

The second problem is that of overlooking some fundamental error, especially in a paper containing detailed mathematics which it is impracticable to check line by line. It is not unknown for a plausible answer to be wrong, while the false step in the analysis that has given rise to it may be extremely subtle. However, it is possible to overestimate the damage that may be done by the publication of erroneous results. Progress is often made in the understanding of a problem through the subsequent correction of such errors, so that the fallibility of referees may have its long-term value.

Connected with this topic is the use of engineering mathematics as opposed to rigorous analysis. Such mathematics does not worry overmuch about existence theorems and the conditions of convergence, or about the uniqueness of the solution obtained; but it has the great advantage that on occasion it enables the engineer to arrive at the essential form of a solution ahead of the pure mathematician, who may, in fact, be helped by the hint which he thus gains from the engineer. The power of these methods lies in the simplicity with which they can sometimes be extended to more general cases where the rigorous attack encounters great difficulties.

Notation

Returning to the understanding of mathematical papers, there is often the additional difficulty of an unfamiliar notation; and it would be much easier if an agreed system could be universally adopted. However, this is a counsel of perfection and should not be made an end in itself, which would be to confuse convenience with necessity.

On the other hand, although the meaning of mathematics is independent of the notation in which it is clothed, a well-chosen notation can add elegance to the argument and may endow it with a measure of lucidity; but, for this reason, it may be difficult to use an agreed notation in a paper which covers a wide range and contains many symbols that have to be carefully related to one another. It is far more important to describe properly the notation that is being used than to adopt a convention that may be taken too much for granted by the author.

In conclusion, two rather different themes may be considered. The first relates to the use of statistical methods in specific situations. A plea may be made for a sense of perspective in applying these methods. Due account should be taken of the statistical nature of the results, especially where the basic material is very complex.

The second refers to the use of speculative reasoning to establish an elaborate theory. It is possible to be carried away by the argument in one paper, only to find proof in another that the argument was completely wrong because it took no account of some incontrovertible fact. However, it is here that true progress is made, for the authors are rare spirits who venture into the unknown and bring back strange stories of what they have seen.

Gradually the picture takes shape, even though some pieces of the puzzle may at first be ill-defined and be fitted into the wrong places. In this process, the arts of radio and telecommunication will assuredly help to resolve the true shapes of some of the pieces.

Long-distance transmission by waveguide

621.372.8

No doubt all the specialists have by now registered for the Convention on long-distance transmission by waveguide which is to take place in the Institution building on the 29th and 30th January 1959. This article introduces the subject of the Convention in a broad and topical way; and it is expected that a number of non-specialists, having been introduced, will want to carry the acquaintance further by attending on one or both days. Registration forms are obtainable from the Secretary.

Prof. H. E. M. BARLOW, PH.D., B.SC.(ENG.), MEMBER

FOR the transmission of high-frequency energy over large distances by guided waves, we are at present restricted to the use of coaxial cables. While such cables are capable of operating in short lengths at frequencies up to 2 Gc/s, they become unsatisfactory as trunk communication links above about 25 Mc/s because they then suffer excessive attenuation and internal-reflection effects. Even so, these cables form the backbone of our communication network, and they not only have given sterling service for many years but will no doubt continue to meet a vital need.

Crowded out of free space

It is, however, important to look well ahead and to ask ourselves what are the possibilities in the future of supplementing our existing services. Free-space radio circuits will, of course, continue to play their part, but these have the inherent disadvantage that they are susceptible to interference and to the restrictions imposed by the rapidly growing congestion of the ether. The time is probably coming when free-space radiocommunication will have to be strictly reserved for such services as cannot reasonably be provided by other means. It is even now being urged that many channels should be allocated in all parts of the radio spectrum to astronautical purposes.

We must, therefore, give particular attention to guided-wave systems, recognizing that they will probably make a contribution of increasing importance to the services required as time goes on. Coaxial cables can, of course, be duplicated to meet the need for more and more communication channels, but the economics clearly indicates that there is a good case for exploring the possibilities offered by waveguides.

Two forms of waveguide

Much work has already been done on the development of methods by which electromagnetic waves in the higher-frequency part of the spectrum can be constrained to travel from one place to another by a guide of some kind. These so-called waveguides may be regarded as the natural successors of the coaxial cable at the higher frequencies.

There are only two forms of guide at present known to have real prospects of development for the long-distance communication application. On the one hand we have the hollow tubular metal guide of circular cross-section supporting the H_{01} low-loss wave mode, and on the other the single-wire transmission line or surface waveguide. For comparable performance in other respects it is a great advantage to use a screened channel, free from the disturbing influences to which free-space waves or even surface waves are exposed; and consequently the tubular waveguide has generally been regarded as the more promising development.

To take advantage of the low-loss feature of the tubular guide, it is necessary to operate in conditions that make possible the simultaneous propagation of other modes in addition to the wanted one, and unfortunately this leads to the setting up of spurious waves when the smooth progress of the required mode is disturbed. Serious as this can be, such undesirable behaviour tends to have been exaggerated.

A parallel phenomenon occurs in the case of the surface waveguide, resulting in radiation of some of the power transmitted or, conversely, making the circuit susceptible to interference from outside disturbances. In particular, bends in either of these forms of waveguide may present a difficulty.

Looking into the future

While the waveguide, as the transmission medium, is perhaps the key to progress in this development, other aspects, including all the associated equipment, are of equal importance at least. Fortunately, the problems in this respect seem likely to be more amenable to solution by known techniques. Thus the introduction of millimetre-wave carcinotrons capable of frequency modulation over a 30% band by variation of the collector voltage is a significant step in opening up new possibilities.

In spite of all the difficulties, great progress has been made in recent years towards a practical solution of the problem of long-distance transmission by waveguide. In connection with the forthcoming Convention on the subject, a demonstration is to be given of a tubular-waveguide television link.

It would be rash at this stage to speculate about the future. It is clear, however, that we must not make the mistake of basing an estimate of our needs for channels on the known requirements of today. As the transatlantic telephone cable has demonstrated, new facilities create new demands.

Given adequate communication channels, industrial organizations and business houses might well conduct their correspondence by the direct transmission and recording of messages one to another, without the inherent delays of the postal service. A trunk waveguide system having been achieved overland, it is perhaps not too much to hope that this would, in due course, be extended to underwater links, providing for new channels of all kinds.

The time has come to bring together those interested in this development, not only to help the exchange of information about it but also to try to assess more accurately its potentialities for the future. The Convention at the end of January 1959, the programme of which is given on p. 25 opposite, has been organized towards that end.

Programme of the Convention on long-distance transmission by waveguide

THE Convention on 'Long-distance transmission by waveguide', arranged by the Radio and Telecommunication Section, will take place in the Institution Lecture Theatre on the 29th and 30th January 1959. Summaries of the papers to be presented are grouped below according to session. An asterisk denotes that the paper will not be available before the meeting, but preprints of the other papers can be obtained in advance on application to the Secretary. The titles of contributions are marked by a dagger.

Opening session (11.00 a.m., 29th January)

Long-distance transmission by waveguide. Introductory survey (*2820*) by Prof. H. E. M. Barlow, PH.D., B.SC.(ENG.)

A SIMPLE approach to developments is described, against a background of more conventional systems.

Session 2—Theory and performance (2.30 p.m.)

Attenuation and propagation factors of spaced-disc circular waveguide (*2830*) by A. W. Gent, B.SC.

PHASE delay and attenuation are found for a spaced-disc waveguide transmitting circular H_{0n}-modes.

Distortion of information in non-uniform multimode waveguides (*2772*) by A. E. Karbowiak, PH.D., B.SC.(ENG.)

THE theory of electromagnetic wave propagation in mutually coupled parallel lines is adapted for microwave propagation in waveguides simultaneously supporting many modes.

Properties of the H-guide at microwave and millimetre-wave regions (*2834*) by F. J. Tischer

WAVE propagation in the H-guide is investigated, and the field distribution and distribution constants of single- and double-slab guides are derived.

***†Theoretical and experimental investigation of discontinuities in the H_{01}- and E_{01}-modes in circular waveguide** by L. B. Felson and W. K. Kahn

***†An experimental investigation of waveguides for long-distance transmission** by A. E. Karbowiak, PH.D., B.SC.(ENG.), and H. Knight

***†Generalized telegraphist's equation for waveguides of varying cross-section** by G. Reiter

***†Transmission deviations in waveguide due to mode conversion: theory and experiment** by H. E. Rowe and W. D. Warters

Session 3—Measurement techniques (5.30 p.m.)

Spinning-dipole technique applied to the measurement of waveguide modes (*2845*) by Prof. H. E. M. Barlow, PH.D., B.SC.(ENG.), and M. G. F. Wilson, B.SC.

AN instrument for measuring field distribution, and hence the various modes, in multimode waveguides is described.

Survey of methods used to identify microwave fields or wave modes in cylindrical waveguides (*2837*) by H. G. Effemey

METHODS are surveyed and their limitations discussed.

***Testing of circular waveguides using a resonant-cavity method** (*2848*) by A. E. Karbowiak, PH.D., B.SC.(ENG.), and R. F. Skedd

EQUIPMENT for measuring the attenuation of circular waveguides is described, using the Q-factor of a resonator formed by a short specimen short-circuited at both ends.

An equipment for measuring the attenuation of low-loss waveguide transmission lines (*2838*) by D. G. Keith-Walker, B.SC.(ENG.)

APPARATUS and methods used for measuring low values of attenuation are described. The Q-factor method seems the most satisfactory, and frequency stability is discussed.

***†The measurement of spurious modes in overmoded waveguides** by Y. Klinger

***†Research on transmission of TE_{01} wave in circular waveguides in the vicinity of 25 and 35 Gc/s** by M. Thue, J. Bendayan and G. Comte

***†Circular electric waveguide loss by the resonance method** by J. A. Young

Session 4—Special microwave equipment (9.30 a.m., 30th January)

A method of changing the dominant mode in a hollow metal waveguide and its application to bends (*2842*) by Prof. H. E. M. Barlow, PH.D., B.SC.(ENG.)

A METHOD is described for bringing any desired mode, other than the normal dominant one, into dominance.

Experiments on circular H_{01} wave propagation in a curved waveguide filled with an inhomogeneous dielectric (*2841*) by Prof. H. E. M. Barlow, B.SC.(ENG.), PH.D., and D. C. Rickard, B.SC.(ENG.)

THE experiments described show that mode conversion caused by bending a hollow tubular metal waveguide supporting a circular H_{01}-mode can be reduced by an inhomogeneous dielectric filling.

Annular-slot launchers for single-conductor transmission lines (*2836*) by J. Brown, M.A., PH.D., and H. S. Stachera, B.SC.(ENG.)

A SINGLE-CONDUCTOR launcher, consisting of a narrow annular slot concentric with the conductor, is described. The similarity between such launchers and supergain aerials is discussed.

Channel insertion feed (*2840*) by Y. Klinger and L. Lewin

A NEW type of frequency-selective H_{01}-mode transducer in a large pipe is described, which can launch a substantially pure H_{01}-mode and can be used for channel insertion.

Centre-excited type of rectangular TE_{10} to circular TE_{01} mode transducer (*2829*) by B. Oguchi and K. Yamaguchi

A NEW centre-excited type of rectangular TE_{10} to circular TE_{01} mode transducer is described. The insertion loss is 0·35–0·7 dB over a 2 Gc/s band in the region of 24 Gc/s.

***Effect of losses on the modes in a helical-wound waveguide, with application to a mode filter for H_{01} transmission** (*2858*) by G. Piefke

PROPERTIES of waveguide modes for a helix line of finite wire diameter and arbitrary surrounding medium are investigated.

Design of a two-section conical taper in a circular waveguide system supporting the H_{01}-mode (*2833*) by L. Solymar

IT is shown that a two-section conical taper can give a performance superior to that of a simple linear taper. Design information is given for such a taper.

Monotonic multisection tapers for overmoded circular waveguides (*2839*) by L. Solymar

THE advantages of multisection tapers are examined.

***†Small steps in overmoded circular waveguide: design of a half-beat-wavelength transducer** by L. Solymar

Session 5—Construction (2.30 p.m.)

Winding and joining helical-wound waveguide (*2826*) by L. Lewin

A METHOD of making helical waveguides, suitable for short-term field tests, is described, and manufacturing problems are analysed.

***†Waveguide for circular electric mode transmission** by A. C. Beck and C. F. P. Rose

***†Helix-waveguide jacket design** by H. G. Unger

Session 6—Aspects of possible systems (5.30 p.m.)

***Assessment of waveguide performance as a long-distance transmission medium** (*2862*) by A. E. Karbowiak, PH.D., B.SC.(ENG.)

THE special features of waveguides designed for long-distance transmission are contrasted with those of the conventional type. Dielectric-coated and anisotropic waveguides are surveyed.

***Influence and elimination of delay distortion in TE_{01} waveguides for long-range communication** by H. Larsen

STUDY of the limiting length of regeneration section in a pulse-code-modulation system reveals that the lower portions of wide bands of 35–80 Gc/s require additional delay equalization if the regeneration sections are to coincide with the usable repeater sections.

***†Some characteristics of long-distance surface-wave transmission lines** by G. Goubau

***†Some views on system application** by F. J. D. Taylor, M.B.E., B.SC.(ENG.)

History under the floorboards

621.3.011

An account of the recent discovery of some Heaviside papers

The unique series of Heaviside manuscripts, which with Heaviside's books forms one of the treasured special collections of the Institution Library, was acquired from his family in 1927, after Heaviside's death. Examination showed, however, that there were gaps in the sequence of papers, and widespread inquiries were made. Towards the end of 1957, three sackfuls of manuscripts, galley proofs and other papers were discovered under floorboards in the house where Oliver Heaviside lived in Paignton, Devon. The author of this article was concerned in sorting the documents, and an Institution Monograph (319) entitled 'The Heaviside papers found at Paignton in 1957', by Mr. Josephs, is published this month (see p. 45). The author is at the Post Office Research Station.

H. J. JOSEPHS, MEMBER

The house in Paignton where Oliver Heaviside lived from 1889 to 1897 and where the papers were found

On the 9th November 1957, Sir Edward Appleton received a letter which began 'I have a sackful of Oliver Heaviside's papers in my garage . . .'. Mr. Harold Saunders, the writer of this letter, who is a chemistry master at a school near Bude, Cornwall, went on to describe his discovery.

Sir Edward Appleton, who at once realized the significance of the find, replied immediately 'I was naturally both excited and delighted by your news . . .' and referred the correspondence to The Institution, who asked Mr. Saunders for permission to send a couple of representatives to Bude to make a preliminary survey of the documents.

Meanwhile Mr. Saunders had started to sort the papers, and on the 23rd November he wrote:

A first inventory of the collection runs like this:

All the papers, dated by their associated envelopes, are between 1892 and 1898.

There are about 2000 sheets of manuscript notes, and they are all reasonably legible, even the worst of them.

There are practically no private papers.

Every foreign envelope has had its stamp removed.

Every envelope from a British source is empty, with the exception of those containing advertisements.

The find

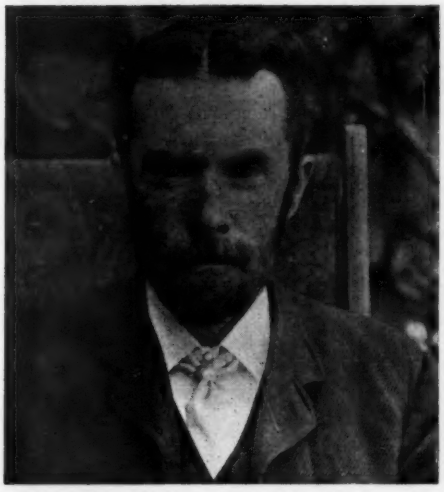
Mr. Saunders received the representatives and gave them every possible help. He had discovered the papers while he and his wife were paying a visit in Paignton, Devon, to their friends Mr. and Mrs. Howard. Mr. Howard had recently been appointed manager of the Paignton branch of Barclays Bank, and his wife, knowing of Mr. Saunders's interest in scientific matters, remarked that a scientist used to live in the house now owned by the bank. Mr. Saunders inquired his name. 'Heaviside' he was told; and his friend explained that there were many of his papers under the floorboards in the attic and that some of the papers could be seen through the spaces between the boards. Mr. Saunders was immediately interested. Continuing the story in his own words:

The following morning I pulled up one of the floorboards and the truth of the statement was confirmed. The papers were almost exclusively in Heaviside's handwriting. They were written on the backs of bills, mainly from music publishers or musical-instrument makers. There were galley proofs of his books and

articles: some uncorrected except for occasional errors in punctuation; some have his mathematics written all over the back. There were about 2000 sheets of manuscript notes, and they were all reasonably legible, even the worst of them. There were few, very few, personal notes; but there were some postcards from Sir Oliver Lodge and a communication from Lord Kelvin. The condition of the papers was somewhat grim; but in the main they were fairly dry (though terribly dusty), and about 90% were easily legible.

At the bank manager's request a builder came in to see me while I was in the middle of removing some of the papers from their hide-out. He told me he was employed there when Barclays took over the premises, and he remembered jettisoning a heap of papers. Then, when he asked his employer what he should do with the rest, he was told to push them down between the joists and nail the floorboards over them. This he did.

Apparently, several persons knew about the Heaviside papers, but at the time of the Heaviside Centenary in 1950 their existence was unknown to the photographer who was sent to take pictures of Heaviside's room. Another report suggests that the building work was being done about the time of the Heaviside Centenary and that the builder, having heard Sir Edward Appleton in his broadcast talk on Heaviside ask for anyone with a knowledge of any Heaviside papers to contact him, may have directed the then bank manager's attention to the papers. However, no further action had been taken.



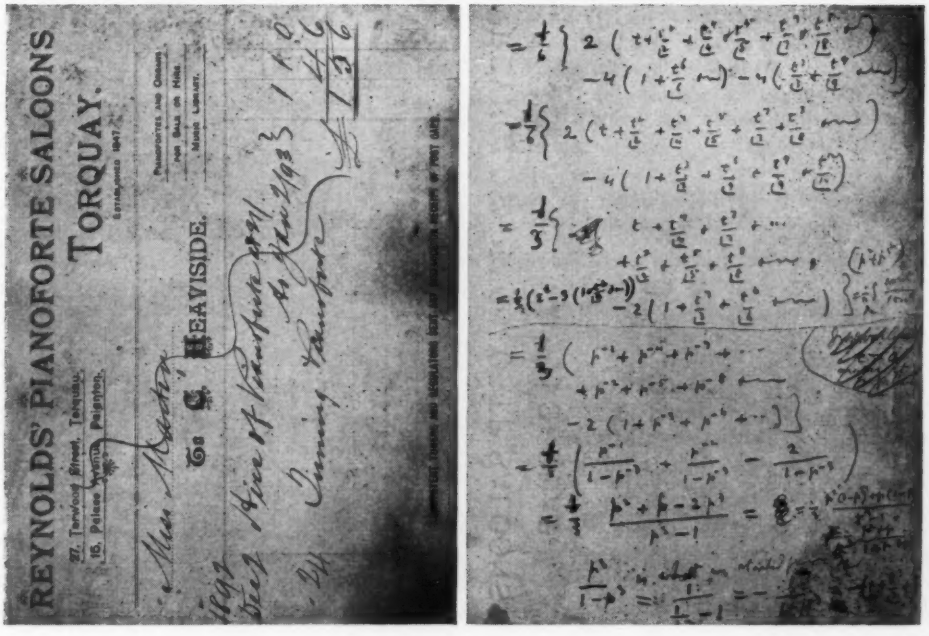
Oliver Heaviside at the age of about 39

A significant year

In 1889 Charles Heaviside took a house in Palace Avenue, Paignton, for the benefit of his parents and his brother Oliver. The shop attached to the house was run as a branch of Reynolds's Music Stores until J. Reynolds ceased to be Charles's partner in 1895. Charles also acquired Reynolds's interests in the Music Stores at Torwood Street in the nearby town of Torquay, Devon.

Oliver Heaviside moved to Paignton with his parents in the autumn of 1889. He appears to have been on very good terms with his brother's children, for one of them who recalled those days at Paignton wrote:

I remember, in the big upper stock-room of my father's music shop, how, with my father playing a march, Oliver,



Some notes on the back of music-shop paper

The three sacks of papers, some spread out

at the head of us, would march round, in and out among the pianos (perhaps a dozen or more), we hanging onto his coat tails in a row, one behind the other!

Oliver was then 39 years of age, short and red-headed.

Apart from this change of environment, the year 1889 was a significant one in the life of Oliver Heaviside. The year began well, for on the 10th January his electromagnetic concepts received complete recognition. On that date, at a Special General Meeting, The Society of Telegraph-Engineers and Electricians confirmed the change of its name to The Institution of Electrical Engineers. Sir William Thomson [Lord Kelvin] took the chair and gave an address on 'Ether, electricity and ponderable matter'. He outlined the history of electromagnetic induction in cable transmission and pointed out that his early theory did not take it into account; then he said:

But in the meantime it had been worked out in a very complete manner by Mr. Oliver Heaviside; and Mr. Heaviside has pointed out and accentuated this result of his mathematical theory—that electromagnetic induction is a positive benefit: it helps to carry the current. It is the same kind of benefit that mass is to a body shoved along against a viscous resistance.

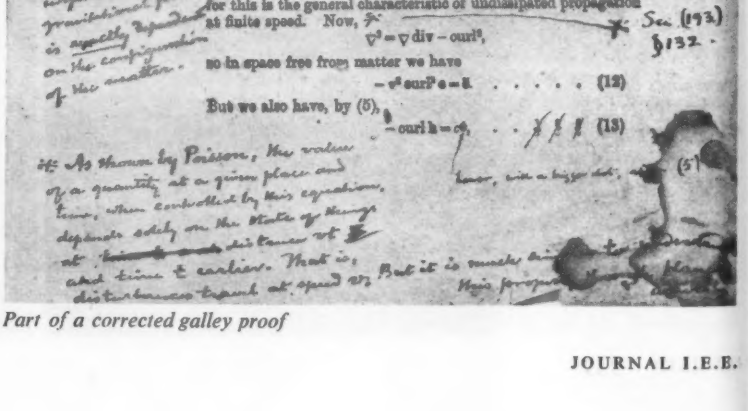
Other results of Heaviside's mathematical researches were discussed at a meeting on the 9th May 1889, when Dr. J. Hopkinson was in the chair.

A fortunate relenting

Before Heaviside moved to Paignton the outlook was dark. In November 1887 he was requested to discontinue his series of papers in *The Electrician*. He wrote: 'A change of editor had occurred, and the new editor asked me to discontinue. He politely informed me that although he had made particular enquiries amongst students who would be likely to read my papers, to find if anyone did so, he had been unable to discover a single one.' In 1889, however, *The Electrician* relented and began to publish Heaviside's papers again.

It was in the same year that Sir Oliver Lodge wrote to Heaviside inquiring if he would allow his name to be put forward as a candidate for the Royal Society. Heaviside at first raised objections to this, but Sir Oliver overcame them, and in June 1891 he was elected a Fellow.

Early in 1891 the editor of *The Electrician* proposed to Heaviside that his series of articles on 'Electromagnetic theory' just begun in that journal should be brought out later in book form. The editor allowed Heaviside great freedom as to what he wrote in his serial articles but insisted that after the first publication in that journal not a word could be changed for the later publication in book form. The editor imposed this restriction in order to keep the costs of production down (for Heaviside's books were not expected to pay) and also because the type set up for the original articles had to be carefully stored (sometimes for years) until the corresponding sections of the book were printed. Since this restriction prevented Heaviside from revising the text of Volumes 1 and 2 of his 'Electromagnetic theory', it follows that



The electromagnetic analogy may be pushed further. It is as incredible now as it was in Newton's time that gravitative influence can be exerted without a medium; and, granting a medium, we may as well consider that it propagates in time, although immensely fast. Suppose, then, instead of instantaneous action, which involves *

$$\text{curl } e = 0, \quad . \quad . \quad . \quad . \quad . \quad . \quad (10)$$

we assert that the gravitational force e in ether is propagated at a single finite speed v. This requires that

$$v^2 \nabla^2 e = \ddot{e}, \quad . \quad . \quad . \quad . \quad . \quad . \quad (11)$$

for this is the general characteristic of undissipated propagation at finite speed. Now, †

$$\nabla^2 = \nabla \operatorname{div} - \operatorname{curl}^2,$$

so in space free from matter we have

$$-v^2 \operatorname{curl}^2 e = \ddot{e} \quad . \quad . \quad . \quad . \quad . \quad (12)$$

But we also have, by (5),

$$-\operatorname{curl} h = \dot{e}, \quad . \quad . \quad . \quad . \quad . \quad (13)$$

* This equation is equivalent to (2) above, and it implies that the gravitational force is wholly dependent on the configuration of the matter.

* To Newton himself, as shown in his often quoted letter to Bentley.

† See (193) §132.

Part of a corrected galley proof

the annotated galley proofs and manuscripts unearthed by Mr. Saunders are of great interest; for they represent Heaviside's second thoughts and show the way he would have revised his text had he had the power to do so.

'Look in the fourpenny boxes'

The publication of this new series of articles raised the question of his earlier papers, the offprints of which were now exhausted. Eventually it was arranged to reprint the whole of his work up to the end of 1890 under the title 'Electrical papers'. 'They printed 750 copies', Heaviside wrote 'and had 359 copies left five years after. They disposed of these at reduced prices, 10s., 2s. 6d., and then all the unbound remainder at 1s. 6d., and so wiped it all out. They can be picked up cheap, because the remainder was sold off in quires for a few pence per volume, on account of the deficiency in storage room. So look in the fourpenny boxes.' However little his papers might be read, he never ceased to produce them. Heaviside worked very hard during the few years he lived at Paignton, and his output was great.

In 1892 he began a close friendship with Dr. G. F. C. Searle of Cambridge, who was the chief support of his declining years at Torquay. This year also saw the publication of the two volumes of his 'Electrical papers'. He was at the same time working on the production of the first volume of his 'Electromagnetic theory', which appeared in 1893. From this date until the time he left Paignton in the summer of 1897, he was working on the second volume of this great work.

Heaviside would do his mathematical work during the quietest hours of the day, starting at about 10 p.m. and continuing until the early hours of the morning. He always worked in seclusion: in order to avoid disturbing him his mother would place his food outside his door. During the day he sometimes conducted electrical experiments with coils and condensers, relays, galvanometers, bridge networks, batteries, etc. Heaviside also kept in close touch with his brother Arthur (who was a divisional engineer in the Post Office) and was consequently well informed in matters of practical telegraphy.

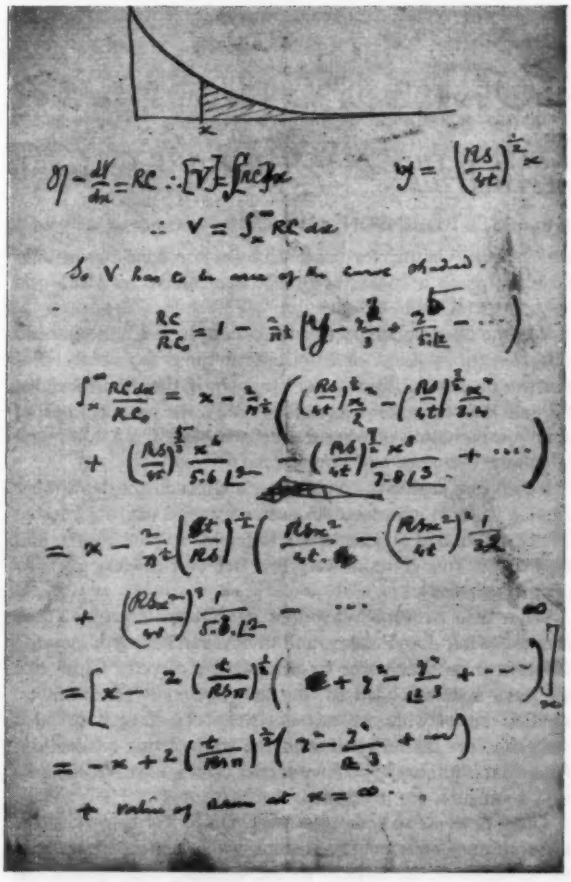
His intuitive genius

During the eight years Heaviside lived at Paignton, his published work contained well over a million words (or their mathematical equivalents). It was as an aid to the understanding of some of this published work that Mr. Saunders's discovery proved useful. In spite of the decayed state of some of the papers that Mr. Saunders unearthed, it was a simple matter to sort and connect them with the corresponding parts of Heaviside's published work. This collation showed that most of the papers under the floorboards could be associated with the publication of Volumes 1 and 2 of his 'Electromagnetic theory'.

An examination of these papers showed that Heaviside had evolved a rigorous justification for his operation of extracting the square root of the process of partial differentiation; for he had discovered the conditions under which his differential time operator p lost its original significance and became the transform parameter of an infinite integral of the Stieltjes type that obeys all the laws of algebra and analysis. These calculations showed that Heaviside preferred to use self-contained methods that did not call for access to books of reference; for the reference facilities available to a poor man working alone in Paignton before the turn of the century were practically nil. Nevertheless, he developed the subject of fractional differentiation much further in some directions than any other mathematician.

Many of the unearthed papers deal with problems connected with the flow of energy. It appears that Maxwell's proposition that light is an electromagnetic disturbance suggested to Heaviside the need for new mathematical concepts to deal with energy-transfer problems. He was seeking new energy-flow vectors with the same or other equally valid postulated electromagnetic energy-densities. It was also found that he had extended Maxwell's theory so that gravitation could be fitted in with electromagnetism.

It must be remembered that Heaviside made the recently discovered calculations when the galley proofs



Notes of unpublished matter

of his 'Electromagnetic theory' were in his hands. Consequently, it was then too late for him to make any extensive changes. On the other hand, it is possible that Heaviside may have thought these changes too trivial to bother about. For Heaviside, like Newton and Laplace, had the faculty of being able to discover difficult theorems by some sort of intuition which dispensed with the usual processes of proof, and it may have been the possession of this gift that made him so contemptuous of formal logic.

Blackberry and apple

During these years he had been living at Paignton with his parents; but his mother died in 1894 and his father in 1896, and he was left alone. Just after his father's death he was granted a Civil List Pension of £120 per annum 'in consideration of his work in connexion with the theory of electricity'. In 1897, Heaviside went to live at Bradley View, a house he rented at Newton Abbot, near Torquay and Paignton, where he tried to look after himself. In a letter to Dr. Searle he described his ability as a cook:

I made some jam the other day out of some apples the boys had not stolen and some blackberries which I could not eat. But I am not fit for a cook; I forget. Then it all goes to a cinder, to be discovered some hours later. Or, if I boil an egg, I am startled by a loud report; either I do not put any water in or else it has all boiled away.

To give a complete and satisfactory report, within the space of a few thousand words, of the significance of the mathematical work on the scattered sheets in the three sacks of paper Heaviside left behind at Paignton, is well-nigh impossible. The most that can be done is to outline the features that became significant during a careful examination of Heaviside's calculations.

It is to Mr. Saunders's credit that he realized immediately that his find was important; and he lost no time in unearthing the papers and getting in touch with Sir Edward Appleton, whose broadcast on Oliver Heaviside he had remembered. The Paignton papers found by Mr. Saunders have now been added to the unique collection of Heaviside's manuscripts treasured in the Institution Library.

CORRESPONDENCE

THE JUNCTION TRANSISTOR AND ITS APPLICATION

From O. D. ROBINSON, MEMBER

I HAVE been waiting for some time for someone to write an article of such a character that it could have as a sub-title 'or transistors without tears'.

We, the all-rounders of the profession, be it admitted, need this elementary kind of information quite frequently. But not (on deeper reflection) more frequently than the specialist himself. The designer of transistors may, for instance, need a simple explanation of what a translator does in an automatic telephone exchange and how it does it.

I therefore read Mr. Wolfendale's effort in the November *Journal* (p. 583) with much eagerness; but he has, alas, somewhat confounded my confusion. Referring to pure germanium he writes: 'This contains very few free carriers (electrons or positive carriers). . . .'

What *is* a carrier? Why does he call an electron a free carrier? What does it carry, and does it carry something quite different from that borne by the positive carrier? Tiros like me have assumed hitherto that an electron is the ultimate, smallest bit of what we call electricity. To have it called a 'negative free carrier' strikes at the root of our conception. And what is it that the positive carrier carries? Mr. Wolfendale will, I am sure, see my point.

There is worse to come, however. On p. 584 he makes this extraordinary statement: 'Current will therefore flow from the positive of the battery to the emitter, holes across the emitter junction to the base, and negative electrons from the negative of the battery to make up recombination in the base.'

One would be entitled to assume from this that two separate and distinct things are happening at the same time in the same circuit: (a) something called 'current' is flowing out of the positive of the battery into the emitter, and (b) something called 'electrons' is flowing out of the negative of the same battery into the base. Is this what is happening? Could it happen? Surely not.

Is not the actual state of affairs either (1) (using the conventional conception) current is flowing from the positive of the battery into the emitter and out of the base into the battery, or conversely (2) electrons are flowing out of the negative of the battery into the base and also out of the emitter into the battery? Accepting the latter as the correct interpretation of the proceedings, the flow of electrons into the base is explained by the need to supply the loss due to recombination. But if electrons flow out of the emitter into the positive of the battery (instead of 'current' into the emitter as stated), where do these electrons come from?

One more point. In the sentence quoted from p. 584, 'negative electrons' make up for the recombination in the base. In the previous sentence to this it is stated that 'electrons' lost in the base are made up from the battery (i.e. performing the identical function). We therefore have these three terms used more or less indiscriminately: electrons; negative electrons; negative free carriers.

Is there any difference between an electron and a negative electron or between either of them and a negative free carrier? If they all mean the same thing, as would appear to be the case, what is the purpose of using all three terms?

Mechanization of thought processes

A SYMPOSIUM on the mechanization of thought processes, held at the National Physical Laboratory from the 24th to 27th November 1958, had over 200 participants from thirteen countries.

In his preliminary remarks to lecturers, Dr. A. M. Uttley (N.P.L.) suggested that the hoary question 'Do machines think?' should be avoided; and the feeling of the gathering was that the remark of one delegate 'No, they are like women, they calculate' was as good a reply as any to such an ill-defined question.

Mistaken insight

The first paper, by Dr. M. L. Minsky (Massachusetts Institute of Technology), discussed, under the heading 'artificial intelligence', ways in which machines may be made to solve problems where the method of solution must be chosen or developed by the machine. Such a machine must certainly deal with non-numerical concepts, and Dr. Minsky has programmed a computer to handle the ideas of Euclidean geometry sufficiently well to prove simple theorems. In his spoken communication he suggested the possibility of a machine with sufficient (but mistaken) insight to be able to deny that it could be a machine and yet do the things it does. Although Minsky's communication was ambitious and speculative, it contained practical suggestions for working towards realization of his ideas.

Further discussion of artificial intelligence was presented by Dr. D. M. MacKay (King's College, London) and Dr. J. McCarthy (M.I.T.). One of Dr. McCarthy's suggestions was that computer-programming systems should be devised in which the computer language is more akin to human language than in existing systems. Programmes might then be developed by an evolutionary process. This could not happen with existing systems, in which the effect of a small change in the programme is usually to disorganize it completely. Dr. McCarthy said that he had never known an error in a programme to produce a 'favourable mutation'.

A contrast was provided by Dr. W. Ross Ashby (Barnwood House, Gloucester), who propounded a mathematical theory for habituation, the simplest type of animal learning, which is shown by such low forms of life as protozoa. His theory appeared to be applicable to the lower forms of life, but Dr. W. Grey Walter pointed out that it was not consistent with all the observed aspects of habituation in humans.

Learning machines

Several papers discussed forms of learning by machines. Systems which utilize a learning process to compute the conditional probabilities of events relative to other events were described by Dr. A. M. Uttley. He suggested that these may model some functions of the nervous system. Dr. F. Rosenblatt (Cornell Aeronautical Laboratory) discussed 'perceptrons', which are self-organizing systems for pattern recognition. They, also, are proposed as models of the nervous system. This paper received some criticism, and it was admitted that some of the mathematical treatment was incorrect.

Dr. O. G. Selfridge (M.I.T.) gave another approach to pattern-recognition utilizing learning. He referred to the recognition of characters in Morse messages, a problem which is seen to be not at all trivial when it is realized that the duration given to a character by an operator is correlated with the message content for ten characters both before and after. Some further ideas for learning machines were put forward by Dr. A. M. Andrew (N.P.L.), who referred particularly to self-optimizing control for industrial processes.

An entirely different approach was that of Mr. G. Pask, who considers that self-organizing machines will eventually use techniques other than those of present-day electronics. A technique is needed which allows a very large number of simple unreliable components to be evolved from undifferentiated material. Mr. Pask has developed a system in which iron is deposited in lines from an electrolyte on the bottom of a container. The system can be 'rewarded' if the pattern of iron is developing in a favourable manner, and configurations of iron can develop to represent 'concepts'. A concept in this sense is some function of the input which can usefully be abstracted.

Sessions of the symposium dealt with automatic computer programming, mechanical language translation, and automatic recognition of speech.

Biological aspects

A particularly interesting session was that which dealt with implications for biology. Dr. Warren McCulloch (M.I.T.) introduced a new logical symbolism to represent the properties of networks of nerve cells. Using this, he showed how networks can give reliable behaviour in spite of variations in properties of individual cells. This may explain how a person can still drive a car after consuming enough alcohol to alter the properties of his nerve cells considerably.

Dr. A. J. Watson (Cambridge) described some aspects of animal learning based on experiments with rats in mazes. He pointed out that if learning machines are meant to be models of animal learning their makers should be aware of this kind of work. One feature of animal learning which is not usually incorporated in machines is exploration without motivation—machines do not usually acquire knowledge for its own sake.

Dr. H. B. Barlow (Cambridge) discussed the coding of sensory information in the nervous system. This appears to involve a process similar to learning, since the form of coding depends on the statistical properties of the information. Dr. Barlow suggested that, in our present state of knowledge, study of this coding is likely to be more profitable than the building of learning machines.

Proceedings of the symposium are to be published by H.M. Stationery Office. In the meantime, anyone interested in any particular paper can write to its author for a preprint.

A. M. A.

A review of the Proceedings, Parts A and B

SHORT REVIEWS OF PAPERS

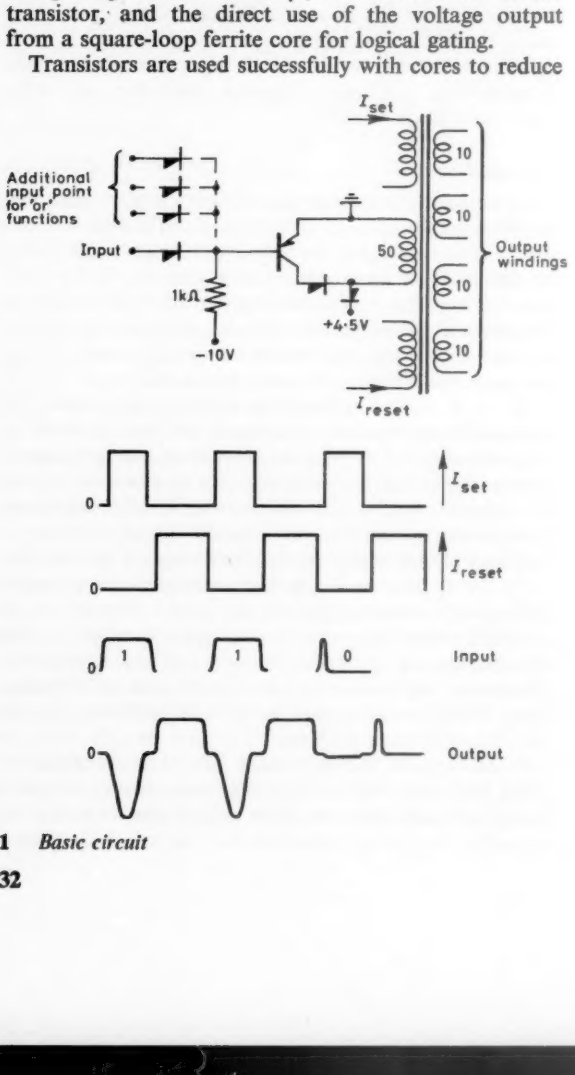
ON the following pages are some brief review articles based on, and written by the authors of, current Institution papers. The authors have been asked to make these articles, so far as possible, interesting and of appeal to electrical engineers who have no specialized knowledge of the subjects, and the content of the articles is not necessarily confined to the subject-matter of the original papers.

New high-speed digital technique

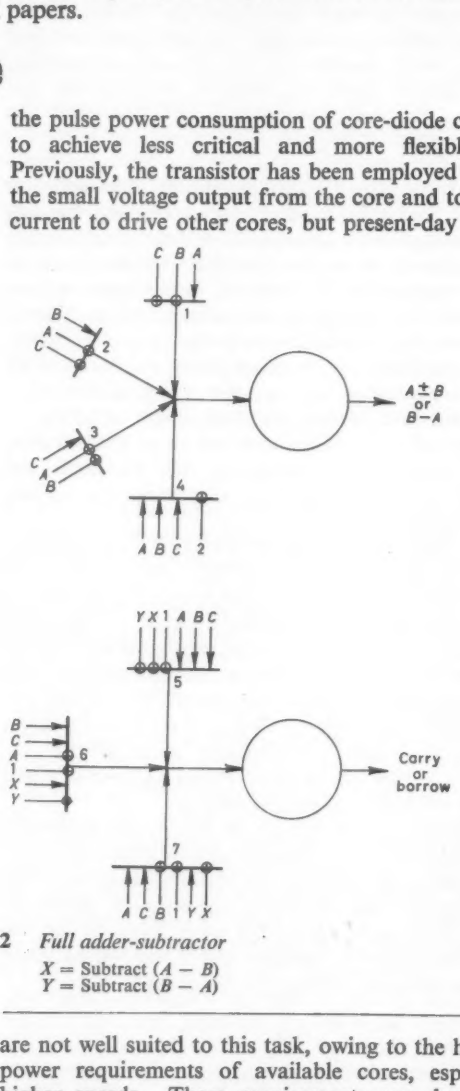
A short review of a Measurement and Control Section paper (2672) entitled 'A new high-speed digital technique for computer use', by D. Eldridge, B.A. The paper was published individually in June 1958, and it will be republished in Part B of the Proceedings. Mr. Eldridge is with I.B.M. British Laboratories and was formerly with Ferranti Ltd.

A NEW core-transistor technique for performing logical, arithmetical, and control functions in digital equipment has been developed, having as its principal features a high digit rate of 500 kc/s, an unusual use of the transistor, and the direct use of the voltage output from a square-loop ferrite core for logical gating.

Transistors are used successfully with cores to reduce the pulse power consumption of core-diode circuits and to achieve less critical and more flexible circuits. Previously, the transistor has been employed to amplify the small voltage output from the core and to provide a current to drive other cores, but present-day transistors are not well suited to this task, owing to the high peak-power requirements of available cores, especially at higher speeds. These requirements can, however, be considerably reduced by driving the cores directly from a common clock supply and using the transistors as switches to control the effect of this source. Transistors are almost ideal switches and in addition can be turned on or off quickly by the small core output. In this way high digit rates can be obtained.



1 *Basic circuit*



2 *Full adder-subtractor*
X = Subtract $(A - B)$
Y = Subtract $(B - A)$

Logical gating with magnetic cores has been performed with considerable economy and reliability. In many cases, a stabilized current, derived directly from the core or from the transistor, is added or subtracted in an analogue fashion with currents from other stages at the input of a square-loop core, the sharp threshold of the latter serving to discriminate the sum. This is an extension of, and derives largely from the use of, such cores in matrix stores. An alternative method, namely summing the voltage output from several cores and using a transistor to discriminate the sum, has been largely ignored, though it has many advantages. In the present technique, logical gating of the analogue-voltage type is combined with the use of a transistor as a switch to provide a high-speed circuit with considerable flexibility.

Fig. 1 shows the basic circuit. The transistor is connected so as either to short-circuit the core (when the input voltage is negative or zero during I_{set}) or to allow reversal of the core state by I_{set} (when the input is positive during I_{set}). In the following period, I_{reset} resets the core to '0', giving one of the two outputs '1' or '0' as shown. The negative portion of the input voltage is not shown, since this occurs during I_{reset} and is not significant. Similarly, only the output during I_{reset} is significant to the following stage, which is driven by two other current waveforms of opposite phase. Both '1' and '0' outputs are of the same defined amplitude, but the short '0' output is ignored by a following stage. Logical operations are performed by the analogue addition of the voltages appearing across the output windings.

Examples of the logic are shown symbolically in the full adder-subtractor (Fig. 2). A, B, and C are the inputs and may each take the value 1 or 0. A and B represent the numbers to be summed, while C is the 'carry' or 'borrow'. The upper part of the Figure shows a circle representing the circuit arrangement of one basic unit, except the input diode(s). Logically this is a half-digit delay but gives a standardized output as described above. Gate 1 represents the analogue sum $A - B - C$ and is formed by connecting one output winding from each of the stages A, B and C in series. However, A is connected in phase so as to drive the input point positive (hence it is shown terminated by an arrowhead), while B and C are connected in antiphase (shown terminated by a circle). The input to the unit from this gate is significant (positive, i.e. $+1$ or more) only when $A = 1, B = C = 0$. Similarly, gates 2 and 3 give an input when $B = 1$, $A = C = 0$, and $C = 1, A = B = 0$, respectively. Gate 4 is a 3-input 'and' gate. The circle indicated by a '2' represents two antiphase windings from a 1's generator in series. Input is only positive when $A = B = C = 1$. The analogue gates 1 to 4 are applied, respectively, to four input diodes (Fig. 1) forming an 'or' function of the four analogue inputs. It is easily confirmed that the output from the half-digit delay is $(A \pm B)$ or $(B - A)$, all of which are identical.

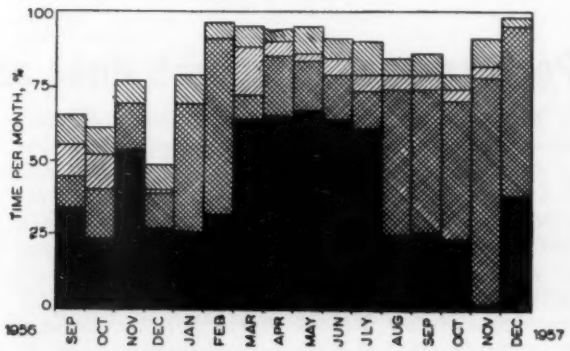
The lower stage provides the appropriate 'carry' or 'borrow'. The 'carry' (gate 5), when adding $(X = Y = 0)$, is simply $A + B + C - 1$, which is a two-out-of-three gate.

621.374.32 : 681.142

Transistor digital computer

A short review of a Measurement and Control Section paper (2593) entitled 'Operating experience with a transistor digital computer', by R. C. M. Barnes, B.Sc.(Eng.), Associate Member, and J. H. Stephen, Ph.D., Graduate. The paper was published individually in April 1958, and it will be republished in Part B of the Proceedings. The authors are at the Atomic Energy Research Establishment, Harwell.

WORK on transistor circuits for computers began at the Atomic Energy Research Establishment in 1953, when only point-contact transistors were available in this country; and assembly of a small digital computer started in 1954 with the dual object of gaining experience in the use of transistors and producing a useful computer. By mid-1955 an experimental model of this computer was running on test programmes. It was described in three papers presented at the Convention on Digital-Computer Techniques in April 1956, and was included in the Convention visits to computer installations. Since August 1956 it has been running continuously, as far as possible, on productive computing or on repetitions of previous problems. Most of the productive computing has been on one problem, and no serious attempt has been made to write a library of subroutines. This record of 18 months' computing service with an all-transistor computer is rare, if not unique, and forms the main subject of the present paper.

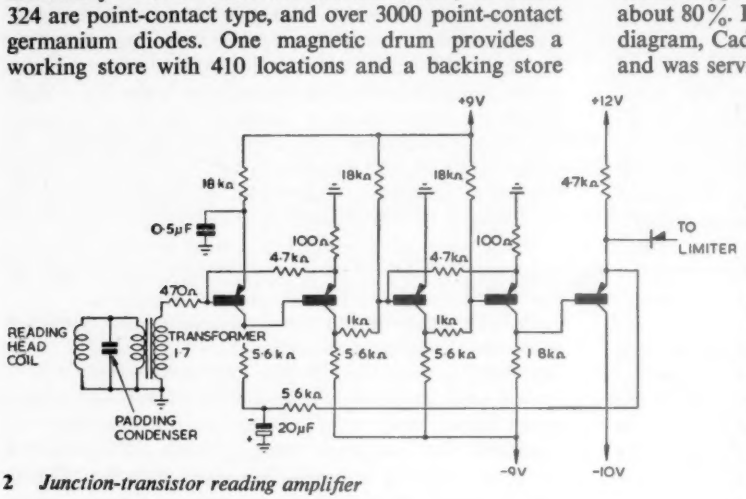


1 *Serviceability of Cadet*

- Switched off
- Unserviceable: maintenance in progress
- Unserviceable: maintenance required
- Serviceable: non-productive
- Serviceable: productive computing

The computer, now named Cadet, is mounted on a laboratory bench. There are 400 transistors, of which 324 are point-contact type, and over 3000 point-contact germanium diodes. One magnetic drum provides a working store with 410 locations and a backing store with very slow access to 16 384 locations. An addition, including reading the instruction and two operands from the store and returning the result to the store, takes 15 millisec, and a multiplication takes 52·5 millisec. Most storage locations are accessible for reading or writing only once in each drum revolution, and the over-all computing speed depends to a large extent on the skill of the programmer in placing numbers and instructions where they are available with minimum delay. In a typical programme the computer performs about 27 arithmetical operations in a second.

Cadet runs without attention at night and during the week-end, and is seldom switched off. The running log is summarized in Fig. 1. Cadet has been switched on for about 90% of each month and has been serviceable for about 80%. In January 1958, which is not shown on the diagram, Cadet was switched on for 100% of the month and was serviceable for 95%. The transistor failure rate was at first as high as 37 transistors in eight months, but in the following 11 months only six transistors were replaced. Failures of other components were negligible. The magnetic-drum store has often been troublesome, for reasons which are known and which could mostly be overcome by changing the mechanical design. Preventive maintenance is based on a daily routine in which a set of self-checking test programmes is run while the transistor circuits are operating under adverse conditions. The test normally requires no attention and has detected many incipient transistor and store failures before they produced errors in service.



2 *Junction-transistor reading amplifier*

Improved junction transistors have become available since Cadet was designed and have been used in circuits such as the amplifier shown in Fig. 2, which has a current gain of 11 000 and h.f. cut-off at 200 kc/s. The amplifier has two pairs of h.f. transistors in common-emitter connection, with current feedback over each pair, followed by a fifth h.f. transistor as an emitter-follower output stage. D.C. feedback over the whole amplifier stabilizes the operating points.

The experience with Cadet suggests that a very high order of reliability may be expected from computers using modern junction transistors, which are known to be more stable and robust than the point-contact transistors in Cadet. 681.142 : 621.382

Performance of speech links and telephone networks

A short review of two Radio and Telecommunication Section papers (2605 and 2666) entitled 'Assessment of speech-communication links', by D. L. Richards, B.Sc.(Eng.), Associate Member, and J. Swaffield, Ph.D., B.Sc.(Eng.), Member, and 'Rating of speech links and performance of telephone networks', by J. Swaffield and D. L. Richards. The papers were published individually in April and June 1958, respectively, and they will be republished in Part B of the Proceedings. Mr. Richards is in the Post Office Engineering Department, and Dr. Swaffield is at the Joint Speech Research Unit of the Post Office.

IT is about 80 years since the telephone began to provide regular conversational communication over substantial distances, and since then 'speech links' of many different types from 'walkie-talkie' radios to transatlantic telephone cables have been developed for both commercial and defence purposes; in the meantime, the public telephone network itself has grown to enormous size—about seven million telephones in United Kingdom alone—and for this reason the links and the equipment generally that go to make up ordinary telephone networks still have a dominant position in speech-transmission studies.

Economical design of speech links should ensure that conversational speech is always possible with sufficient ease to satisfy the users' needs but is attained at minimum cost; sound design in this sense is extremely difficult to achieve even when, as in telephone systems, the work is on a scale sufficient to justify considerable investigation. One reason is that there are no simple absolute terms in which the user can give a performance specification or user requirement for the designer to work to. Statements of the form, say, 'a 20 h.p. motor is needed for this purpose' are taken for granted elsewhere, but corresponding statements, e.g. that 'x% speech intelligibility is required for this purpose', that would serve to tie

together the use, performance and design aspects are lacking for speech links. Failing practical absolute measures, comparative methods have to be used. Another difficulty in design is that we are more often concerned not with individual speech links but with 'systems' or 'networks', i.e. relatively large assemblies of switched speech equipment whose transmission performance must largely be treated statistically in terms (such as the proportions of conversations at various levels of satisfaction to the users) that are not directly helpful to the designer. The study of systems must take account of uncontrollable factors, such as user behaviour and acoustic noise, as well as quasi-controllable ones, such as circuit noise and engineering tolerances.

In the face of these difficulties the subject of transmission performance of speech links is broken up into four types of study.* Information from each is complementary but arranged so that, as a whole, it gives a coherent design basis—especially for large systems. The first two studies are concerned with individual speech links (i.e. complete single conversational paths):

(1) Rating

Rating is the assignment of numerical quantities representative of performance in terms useful for detailed design purposes. Ratings are expressed relative to some particular physical 'standard' speech link. Rating scales are constructed in terms of equivalent amounts of some design factor or impairment, such as signal/noise ratio or attenuation.

(2) Assessment

Assessment is essentially the 'clinical' support for rating studies; it is the name given to laboratory measurements using subjects and resulting in 'scores' (e.g. percentage of sentences correctly understood). By a series of assessments of an unknown link and a standard with the use of graduated impairments, the rating, as in (1), of the unknown link can be determined.

The other two studies are concerned with networks or systems, i.e. aggregates of speech links:

(3) Performance of systems or networks

By knowledge of such things as (a) the extent to which the link used as a standard [see (1)] is representative of the transmission of the system, and (b) the distribution of telephonic ability between persons using the same speech link [obtained during (2)], it is possible to calculate a statistical measure (known as 'network transmission performance') of the performance of the system as a whole.

(4) User evaluation

User-evaluation studies concern the nature of users' satisfaction with the transmission service of a system under operational conditions.

The temptation to measure the performance of an individual speech link in terms of some quantity that can be identified with 'fractions of information, such as words or sentences, correctly received' over the link has always been strong, but proves to be rather analogous to assessing a transport service solely by the criterion 'fraction of goods received undamaged'. Though a high assessment would indicate some kind of merit, its main use would be to discriminate between services all so bad that 'goods damaged' was the dominant aspect of the service. With speech transmission a wide range of links—from some that would be described as of 'high quality' down to others providing only moderate commercial-quality speech—all yield scores of nearly 100% with measures of the 'fractions correctly received' type. This sort of measure is thus very insensitive over much of the useful range of speech quality and is of very limited value to designers and practically none to users; the difficulty can, as will be seen below, be overcome by deriving 'ratings' indirectly from assessment scores. Another reason for the restricted useful range of a simple assessment score of the above type is that it quite fails to evaluate the mental wear and tear on the subjects talking over the link in attaining these high scores in the regions of medium (or better) speech quality. Such assessments fail yet again with poor speech quality because scores based on listening to 'one-way' spoken material are often unreasonably low and do not in any case realistically represent conditions when the speech is so degraded by noise or distortion that practically nothing can be understood unless the subjects fully exploit the artifices of conversational exchange (repetition, discussion, amplification, paraphrase, etc.). A both-way conversational

Table 1. Classification of speech-link performances to provide a framework for a general assessment method

Class	One-way speaking		Two-way conversation		Rough description of transmission performance[2]
	Extent to which link distinguishable from noiseless direct airpath	Listening effort	Conversational effort	Message rate[1]	
1	2	3	4	5	6
(*a*)	Barely or not at all[3]	None	None	Normal	Perfect
(*b*)	Appreciably	Slight or none[3]	None	Normal	Excellent
(*bc*)	Completely	Appreciable	Slight or none[3]	Normal	Good
(*c*)	Completely	Inapplicable. One-way tests of little value	Appreciable	Slight or no reduction[3]	Fair
(*d*)	Completely		Considerable	Appreciable reduction (more than 5%)	Poor or useless

[1] 'Message rate' is measured by timing the performance of a definite task which must be performed using the speech link

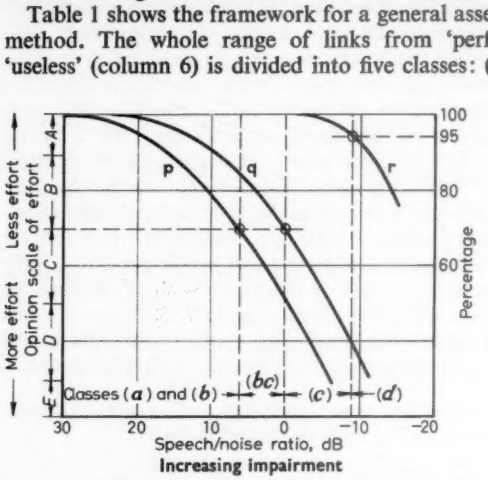
[2] The terms in column 6 are loose descriptions only and do not form part of the description of the classes. They are roughly in accord with a comment which might be made by an 'average man' using the link for a brief conversation under conditions free from physical stress. They must not be taken as a guide to user evaluations

[3] The phrase 'slight or none' is taken to mean that less than 5% of material requires, on the part of an 'average man', the type of effort to which the column refers. Similarly, slight or no reduction in 'message rate' means up to 5% reduction. A similar meaning is attached to 'barely' in column 2

* The four studies together define the ground covered by Paper 2605; Paper 2666 is devoted to a more detailed account of assessment work, i.e. the second of the four studies in the above list

assessment technique is essential in the range of poor performances. As speech quality changes, so the method of scoring and indeed the whole measurement technique must be changed if useful results are to be achieved.

Table 1 shows the framework for a general assessment method. The whole range of links from 'perfect' to 'useless' (column 6) is divided into five classes: (*a*), (*b*), (*bc*), (*c*) and (*d*) (column 1), and the boundary between any two classes is defined in terms having relevance to the mode of conduct of conversation at that level of performance. Columns 2–5 refer to the assessment measures used for this purpose and show how each fares as the link is degraded through the four boundaries from 'perfect' to 'useless'; each assessment measure in turn marks an interclass boundary at the stage when, in terms of that measure, the degradation just becomes 'appreciable'. Fig. 1 shows, rather simplified, the results of some tests to locate some of the boundaries. Speech/noise ratio is in this case the variable design factor, and the curves are therefore of assessment measure as a function of speech/noise ratio. The tests used in connection with column 3 of Table 1 to determine the (*b*)/(*bc*) interclass boundary are based on one-way speaking which takes the form of groups of sentences read over the link; this is sufficient here because anywhere above the upper boundary of class (*bc*) the speech can be fully understood without conversational exchanges or requests for repetitions etc. Listening subjects indicate opinions of the transmission on a 5-point effort scale which is explained to them; the five levels of effort are indicated by A, B, C, D, E. Results averaged over a sufficient number of subjects give curve (p), and the transition from opinion B to C, as the impairment is increased, marks the change of listening effort from 'slight or none' to 'appreciable' (see Table 1) and so locates the interclass boundary.



1 *Assessment measures, as functions of speech/noise ratio, used to define interclass boundaries*

p Listening effort (left-hand scale)
q Conversational effort (left-hand scale)
r Message-rate efficiency (right-hand scale)

The (*bc*)/(*c*) and (*c*)/(*d*) interclass boundaries can be determined by comparable, though more difficult, experimentation; fully conversational tests using the both-way link are essential here for the reasons indicated above. Purposeful conversation is generated by giving the subjects a definite task to perform for which detailed conversational co-operation is essential. This enables two further curves (q) and (r) to be derived, dealing respectively with conversational effort and with rate of conveying 'message' information. These curves, in conjunction with Table 1, serve to determine the two other main boundaries of interest in telephony. The three boundaries are marked on Fig. 1.

The experimental conduct of assessment techniques developed on these lines tends to be elaborate; the work demands carefully devised and controlled equipment conditions (including the maintenance of ambient noise at each end of the links under test), a supply of unbiased subjects and a rigorous experimental drill and analysis of results. Fig. 2 shows a typical test position where a number of different assessments are in progress.

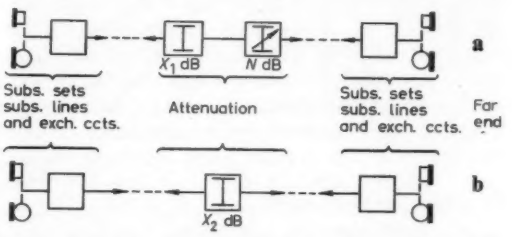
2 *Typical test position with a number of different assessments in progress*

The scores which the three assessment measures already illustrated provide are also suitable for use in determining ratings; in addition, however, other simpler assessment techniques such as those yielding 'articulation efficiency' can, once the boundary positions are known, often be used in particular circumstances.

Fig. 3 shows how any appropriate assessment technique that yields a score varying as a function of impairment can be used to derive a rating of an unknown link in terms of a standard. Link (*b*) is here the 'unknown', and (*a*) is the standard and has incorporated in it as a variable the form of impairment, in this case N decibels of attenuation, in terms of which the rating is desired. When the two links shown have equal transmission performance, i.e. if their assessment-measure 'scores' are equal, the rating of link (*b*) is said to be $-N$ decibels, or N decibels worse than standard. For several reasons, practical methods of using assessment techniques for rating tend to be more complicated than this; it is in any case not generally possible to balance two links directly

as the Figure implies. Great importance attaches to the choice of a suitable transmission standard. Its transmission datum (see Fig. 3) should represent in some clearly understood way the performance desired for the working system in which the equipment is to be used.

The application of ratings can be extended from complete individual links to include their components and other factors affecting transmission; and under most practical conditions, provided that a suitable rating scale has been chosen, ratings of more-complicated links can then be derived by calculation from those of simpler links, components, etc. By the extension of these



3 *Rating of a speech link in terms of a link of comparable type used as a standard*

a Standard speech link. It includes specification of ambient noise at both ends. Attenuation N is variable and may be positive or negative; $N = 0$ gives datum transmission

b Link being rated. Ambient noise at both ends affects rating and must be stated

processes, networks, including the effects of circuit and acoustic noise, microphones, earphones, side-tone circuits, etc., as well as local, junction and trunk line-transmission equipment, can be planned.

These methods, particularly if they are applied continuously to the detailed planning of a gradually expanding network, can certainly ensure, say, that nearly all calls enjoy the equivalent of 'datum' transmission or better; but they do not, especially in view of what has proved to be the wide range of 'conversational abilities' of telephone users, provide material for a very comprehensive picture of the likely performance of the network as a whole. The type of performance study noted in (3) above does, however, enable this to be done by connecting detailed data concerning the telephone performance of subjects with distributions both of room-noise levels and of ratings (associated with the plant layout and the switching plan of the network). A typical complete performance estimate is shown in Table 2; this is based on data relating to the British Post Office network but does not refer to its exact layout at any one time. It will be seen, first, that although combinations of unfavourable circumstances can produce poor, i.e. class (*d*), calls, the many factors that have to be simultaneously adverse yield only a small chance of this happening, and secondly, that in any case nearly all poor calls occur where the equipment itself is providing much better than limiting transmission. For example, the 3200 poor calls (0·2% of 1 600 000) which the top-right cell implies compares with the solitary poor call (15% of 4 calls) that can be inferred from the bottom-right cell where the equipment conditions are very unfavourable.

Only when the whole network or system is a going concern operationally can its full transmission merits or defects really be evaluated. User evaluations of this kind form a distinct study; their purpose is to provide a broad check on the more abstract and detailed network transmission-performance estimates and to build up confidence that the transmission standard used in rating and planning the network is realistic.

Table 2. Typical transmission performance of a telephone network

Type of calls	Approximate number of calls per week in the class (B.P.O. network, April–June 1954)	Proportions of calls which fall into various classes as defined in Table 1		
		Classes (*a*) or (*b*)	Classes (*a*) (*b*) or (*bc*)	Classes (*a*), (*b*), (*bc*) or (*c*)
1. All calls involving at least two Zone Centres	1 600 000	89%	95%	99·8%
2. All calls involving at least two Zone Centres and one 'fringe' exchange*	26 600	64%	86%	99%
3. As 2, but subscriber on 'fringe' exchange has near-limiting exchange line	2 000	50%	80%	97%
4. Calls between two remote 'fringe' exchanges*	700	47%	79%	97%
5. As 4, but both subscribers on near-limiting exchange lines†	4	about 10%	51%	85%

* A 'fringe' exchange is one whose access to its Zone Centre is through the greatest permitted number of links

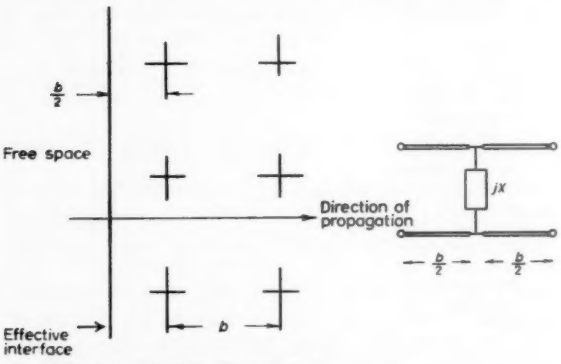
† 'Near-limiting exchange lines' here means greater than 0·85 of the limiting line length; such lines usually comprise about 7½% of the total

By use of all these methods it is possible to design and to extend speech-communication networks on a very large scale or to introduce quite new types of transmission equipment while retaining the ability to estimate and control the performance of the whole system. The power to plan transmission performance is valuable both with large static systems of slow growth, such as public telephone networks, and with smaller systems containing comparatively new equipment, especially if quick and flexible construction is important, as in defence communications. 621.391:621.395.5:621.395.813:621.395.74

Applications of artificial dielectrics

A short review of three Radio and Telecommunication Section papers (2735, 2736 and 2742) entitled 'The use of dispersive artificial dielectrics in a beam-scanning prism', by J. S. Seeley, B.Sc.(Eng.), Ph.D., Graduate, and J. Brown, M.A., Ph.D., Associate Member, 'The quarter-wave matching of dispersive materials', by J. S. Seeley, and 'Theory of reflections from the rodded-type artificial Dielectric', by A. Carne, B.A., M.Sc., and J. Brown. The papers were published individually in November 1958, and they will be republished in Part B of the Proceedings. Dr. Seeley was formerly in the Department of Electrical Engineering, Imperial College of Science and Technology, and is now at the Royal Aircraft Establishment; Dr. Brown is Reader in Electrical Engineering, University College London; and Mr. Carne is with the Metropolitan-Vickers Electrical Co. Ltd.

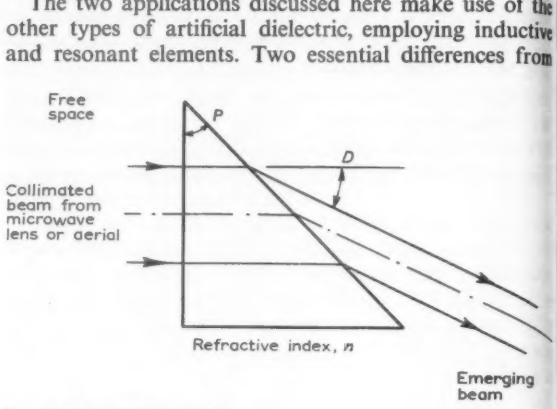
THE development of new techniques in engineering is governed by the availability of suitable materials. Some years ago, it was suggested that 'artificial dielectrics' could be used as refracting materials in the construction of microwave lenses in place of solid dielectrics, such as low-loss plastics. The principal advantages gained by this are reductions in weight and cost. The work described here arose from a detailed study of the properties of artificial dielectrics and illustrates two other potential applications.



1 *Behaviour of artificial dielectrics*
a Arrangement of artificial dielectric
b Equivalent circuit of one section

Artificial dielectrics are arrays of conducting elements spaced regularly in a lattice which, when polarized by an electromagnetic wave, exhibit the refracting properties of a solid dielectric. Their behaviour is deduced from the equivalent transmission-line circuit illustrated in Fig. 1, where jX represents the shunt reactance of each layer of elements and can be inductive, capacitive or resonant, depending on the shape of the elements and their polarization by the electromagnetic field. Arrays using capacitive elements are non-dispersive (i.e. their refracting properties do not change rapidly with change in frequency).

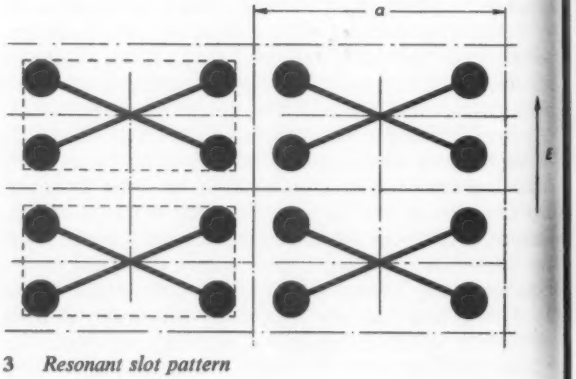
The two applications discussed here make use of the other types of artificial dielectric, employing inductive and resonant elements. Two essential differences from the capacitive type are that the arrays are highly dispersive and exhibit values of refractive index less than unity. These two properties are used in the applications to be described.



2 *Beam-scanning prism*
P = Prism angle D = Deviation

A material which is highly dispersive could be used in the prism for beam scanning shown in Fig. 2. The angle at which a beam emerges from such a prism is determined by the refractive index, n. If the material forming the prism is highly dispersive, the direction of the refracted beam can be varied by altering the frequency of the microwave. Thus suitable frequency modulation would lead to beam scanning without moving parts.

When the refractive index of an artificial dielectric is less than unity, its wave impedance is greater than the free-space wave impedance. If the array is contained in a solid dielectric, the impedance of the composite material may be equal to the free-space impedance at two frequencies. Surface reflections from such a material would be eliminated at these frequencies, so that a radome

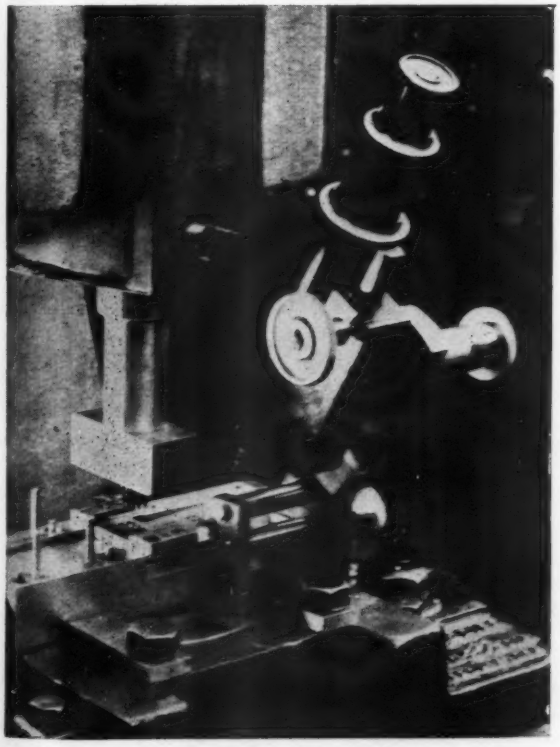


3 *Resonant slot pattern*

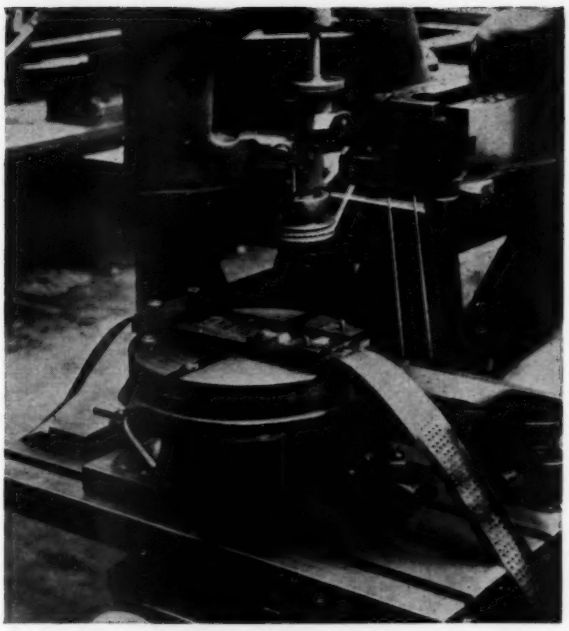
could be designed on this basis to be almost 'invisible' over wide changes in frequency and angle of incidence.

The simplest elements to use in an inductive artificial dielectric are copper rods aligned with their axes parallel to the electric vector of the incident wave. This type of artificial dielectric has been investigated as a non-reflecting material because the theory of its operation is known and small-scale samples are easy to fabricate. The same array, and also an array of resonant slots, have been examined in considerable practical detail for use in a dispersive prism. The elements for the resonant array were sheets containing the pattern of slots shown in Fig. 3, which in the final stages were reproduced by photo-etching to give a slot width of only 0·002in. The dimension a was varied deliberately in preliminary experiments to find the connection between the length of the individual slots and the resonant frequency of the sheets, the pattern of slots for these experiments being machined by punching and engraving. Figs. 4 and 5 illustrate the processes being carried out. This method produced strips of slots adequate for the purpose.

It was considered essential to obtain experimental data from samples of the rodded and resonant dielectrics in order to establish the levels of attenuation in the materials and the limitations of the theoretical dispersion. Attenuations of up to 1dB/cm were measured at 27Gc/s with both artificial dielectrics. Reasonable agreement was recorded with the theoretical behaviour of both materials,



4 *Punching holes for patterns of resonant slots*



5 *Engraving patterns of resonant slots*

but with an important qualification in each case near the limiting value of dispersion. This situation is reached with the rodded dielectric as the rods are spaced further apart and increased in thickness until they can no longer be represented by the simple circuit of Fig. 1.

The series capacitance of the rods becomes of same order as the shunt inductance, and the over-all effect is either to reduce the dispersion or to increase the attenuation. In contrast, the dispersion of the resonant array is increased by reducing the spacing of the elements to the minimum. Experiment has shown that this close packing modifies the resonant properties of the slots in such a way as to reduce their effectiveness as dispersive elements. A design for high dispersion using this array must, therefore, be based on empirical information.

The surface reflections from dispersive materials used in aerial systems will obviously vary with frequency and can rise to intolerable limits unless suppressed. A matching quarter-wave layer can be designed by varying the spacing and dimensions of the last row of elements. This layer can be made to match over a wider bandwidth than a straightforward layer, since the frequency-dependence of the elements can compensate for the variation in impedance of the dispersive material.

The two applications of artificial dielectrics discussed here have been shown to be feasible and could be quickly developed in detail if a specific need arose. Manufacturing methods would need careful study, but production on a large scale should be easier than the making of laboratory samples. In the course of the investigation further valuable information on the behaviour of artificial dielectrics has been obtained.

621.396.965.4 : 621.396.677.852 : 621.396.677.859 : 621.371

Electrification of U.K.A.E.A. factories

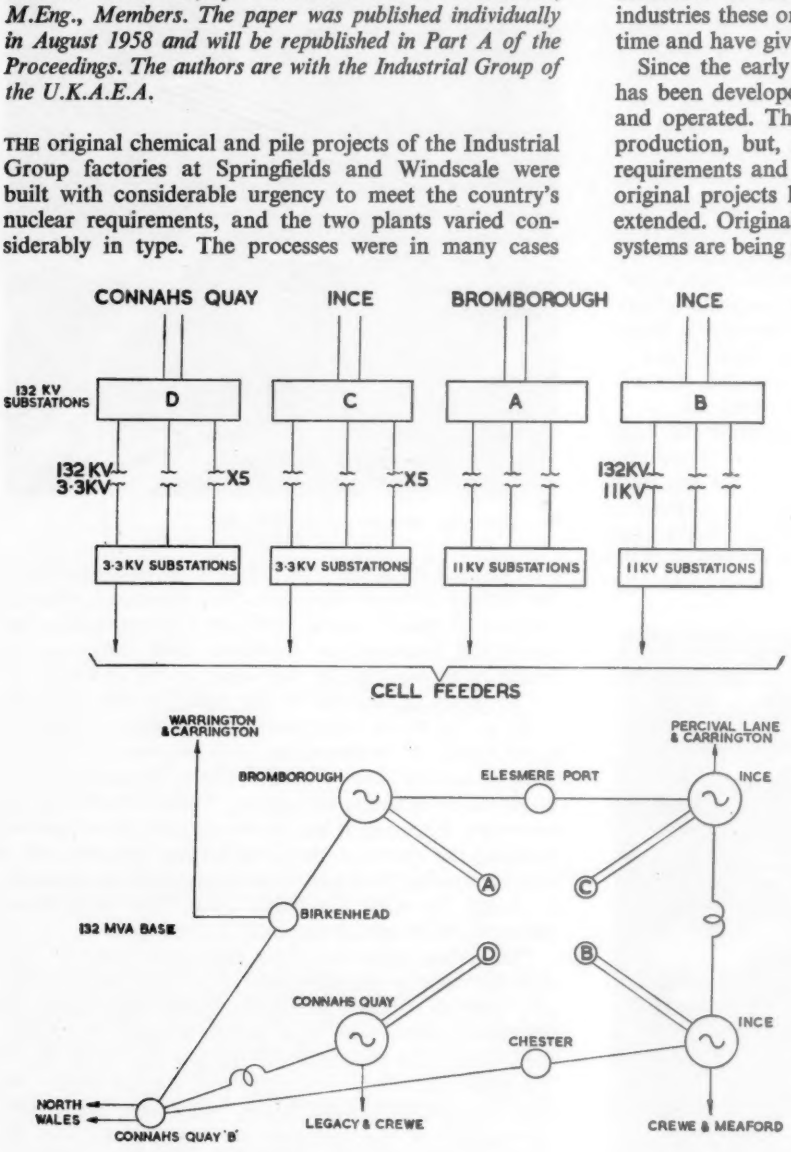
A short review of a Utilization Section paper (2698) with the above title, by J. W. Binns and W. J. Outram, M.Eng., Members. The paper was published individually in August 1958 and will be republished in Part A of the Proceedings. The authors are with the Industrial Group of the U.K.A.E.A.

THE original chemical and pile projects of the Industrial Group factories at Springfields and Windscale were built with considerable urgency to meet the country's nuclear requirements, and the two plants varied considerably in type. The processes were in many cases quite new, and design work proceeded very little in advance of building, construction and plant erection.

It followed that the provision of electrical services was often made without any very clear picture of possible future trends, while at the same time specifications for acceptable standards of equipment to meet different and sometimes novel needs were being formulated. Original ideas for chemical-plant electrification were based on heavy-chemical-industry practice, and through the ready assistance of the electrical manufacturing and supply industries these original installations were completed on time and have given good service.

Since the early days, the Capenhurst diffusion plant has been developed and the Calder power station built and operated. The emphasis has been more on power production, but, in keeping with additional chemical requirements and the Authority's commitments, all the original projects have been, or are being, considerably extended. Original 6·6 kV chemical-factory distribution systems are being reinforced and where possible changed over to 11 kV operation. All this development has taken place within the past 12 years.

Owing to the nature of the materials handled, particular attention has been given to ventilation and the maintenance of service supplies to these installations at all times. Plants are designed and equipment installed so as to promote a very high degree of cleanliness, electrical equipment being, where possible, situated



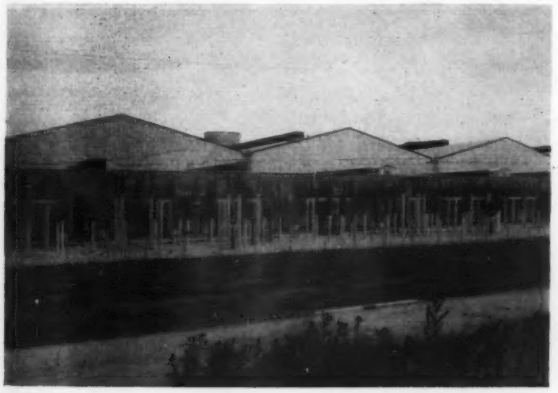
1 *Diagram and equivalent network of main supplies, Capenhurst*

outside process areas to facilitate maintenance. Buildings have been designed with service corridors.

On pile installations, cooling and an emergency supply are important factors and have necessitated the provision of specially designed emergency-supply arrangements involving large storage batteries of up to 2000 Ah capacity with standby Diesel-generator sets. The need for safety circuits on reactors embracing the cooling systems and reactor control and shut-down installations has meant close liaison between plant, electrical and instrumentation engineers.

Diffusion-plant requirements have made necessary the installation of much electrical equipment in comparatively small plant areas and with very high load factors. The housing of appropriate transformers and switchgear has played more than the usual part in deciding layout of process plant. The nature of the process materials (uranium hexafluoride) has necessitated high reliability and continuity for the electrical supplies.

Because of the heavy motor load involved with diffusion plants, special problems regarding recovery of the electrical system after external Grid faults have been experienced, and careful sectionalization of these electrical supply systems has had to be incorporated in the design. With the high loadings and need to limit the amount of electrical equipment, supplies have been stepped down in certain cases direct from 132 kV to 3·3 kV, the user voltage for the larger plant drives. Elsewhere, extensive use has been made of 11 kV/415 volt naturally-air-cooled transformers to minimize fire risk.



2 *'D'-Section plant—substation and equipment, Capenhurst*

Switchgear installations are of necessity large, although sectionalization of the boards has been made as far as possible. Design of all substations has included the provision of cable basements, elaborate oil-drainage systems, and the latest carbon-dioxide and/or atomized-water fire-fighting equipment where appropriate, together with necessary alarm systems.

Special water-cooled motors of medium voltage and smaller high-frequency motors are in continuous use.

Electric furnaces and heating installations of all types have been employed and also high-frequency vacuum casting techniques with the appropriate electrical equipment.

3 *Control corridor, Chemical Building, Springfields*

On the fast-reactor project at Dounreay, special problems of sealing service entries to pressure vessels have arisen, mainly with medium-voltage cabling, but on future experimental reactor projects high-voltage cable seals through containment vessels also need special design effort. High-temperature insulation problems for electromagnetic sodium pumps for cooling have occurred.

The need to provide adequate trace-heating on process-gas lines, both for uranium hexafluoride on diffusion plants and on sodium cooling lines for the fast reactor, has made essential the installation of much electrical trace-heating, using in the former case mineral-insulated copper-sheathed heating conductors and in the latter special sheathed elements, suiting the temperature requirements.

In general, and depending on the degree of security needed, process plants have duplicated electrical supply feeders. In the case of the fast reactor at Dounreay, which is situated remote from a main 132 kV supply point and otherwise depends on a lengthy 33 kV feed system, special Diesel generators have been installed to supply the main cooling circuits and essential plant requirements.

Special glove-box techniques with and without the use of manipulators have been developed for element fabrication and the handling and processing of highly active elements.

Main cabling where in buildings has been installed with fireproof serving, and for general small-service wiring it has been found possible in the cleaner buildings to install conduit, although many of the wet-chemical plants have been wired with rubber-insulated single-wire-armoured fireproof cabling. For high ambient-temperature conditions extensive use has been made of mineral-insulated cables. 621.316.17

Power measurement at 4 Gc/s using Hall effect

A synopsis of a Radio and Telecommunication Section paper (2748) entitled 'Power measurement at 4 Gc/s by the application of the Hall effect in a semiconductor', by L. M. Stephenson, B.Sc.(Eng.), Graduate, and Prof. H. E. M. Barlow, Ph.D., B.Sc.(Eng.), Member. The paper is published this month in Part B of the Proceedings. The authors are in the Department of Electrical Engineering, University College London.

WHEN a semiconducting crystal is mounted in the path of an electromagnetic wave, a Hall e.m.f. is set up in the material along the direction of propagation with a value proportional to the power transmitted.

The device operates most satisfactorily when the wave impedance is small, so that for a given power the electric-field component is reduced to a minimum. The use of a resonant cavity with the crystal erected in it at a point of strong magnetic field enables such favourable conditions to be established, and this arrangement forms the basis of the wattmeter described.

The instrument can measure power at 4 Gc/s with an error of $\pm 3\%$ from 30 mW to about 20 watts, with the unique feature that this performance can be achieved on any standing-wave ratio between unity and 0·1 while absorbing only about 3·4% of the power measured.

Some experiments on semiconductors mounted directly in a waveguide are also described, showing the possibility in this case of using several crystals in cascade.

621.317.784.029.64

New low-noise triode for up to 1000 Mc/s

A synopsis of a Radio and Telecommunication Section paper (2761) entitled 'Design and performance of a new low-noise triode for use up to 1000 Mc/s', by A. D. Williams, B.Sc.(Eng.), and D. C. Gore, B.Sc.(Eng.), Graduate. The paper is published this month in Part B of the Proceedings. The authors are with The General Electric Co. Ltd.

THE factors governing the design of a simple glass-base u.h.f. amplifier valve are outlined, and the circuits in which it can be used are considered.

The design of such a valve is described, together with the special techniques which are necessary to obtain reproducibility with inter-electrode clearances of only 40 microns.

Detailed information is given on the stability, noise performance and gain-bandwidth product of the valve over the u.h.f. band. 621.385.3.029.6

Electro-nuclear accelerators

A synopsis of a Radio and Telecommunication Section paper (2768) entitled 'Radio-frequency aspects of electro-nuclear accelerators', by A. F. Harvey, D.Phil., B.Sc.(Eng.), Member. The paper is published this month in Part B of the Proceedings. The author is at the Royal Radar Establishment.

AN account is given of the various forms of electro-nuclear machines for the acceleration of charged particles, emphasis being laid on the radio-frequency aspects of the design and performance. As an introduction, particle electrodynamics and the original d.c. and l.f. accelerators are examined. Linear accelerators in resonant and travelling-wave circuit form are then described. Orbital or cyclic machines, with both constant and time-varying magnetic fields, are considered, and the survey concludes with a bibliography of published information. 621.384.62

H.F. direction-finding errors

A synopsis of a Radio and Telecommunication Section paper (2766) entitled 'An investigation of high-frequency direction-finding errors caused by nearby vertical reradiators', by C. W. McLeish, M.Sc., and R. S. Roger, B.App.Sc. The paper is published this month in Part B of the Proceedings. The authors are in the Defence II Section of the National Research Council of Canada.

THE theory of reradiation from resonant conductors is reviewed, and the susceptibilities to error of three types of direction-finding aerial are compared. Measured errors due to reradiation confirm theoretical values derived from a simple expression in cases of thin linear conductors in simple resonant modes.

621.396.933.2: 621.396.677

Comparator for 100 kc/s frequency standards

A synopsis of a Measurement and Control Section paper (2778) entitled 'A very precise short-period comparator for 100 kc/s frequency standards', by A. M. Thompson, B.Sc., and R. W. Archer. The paper is published this month in Part B of the Proceedings. The authors are in the Division of Electrotechnology, National Standards Laboratory, C.S.I.R.O., Australia.

AN instrument is described for the very precise comparison of 100 kc/s frequency standards. A sensitive phase-comparator is combined with a trigger circuit to produce a timing pulse at the instant the two 100 kc/s signals are in phase opposition. The time interval between successive pulses is determined by a counter-type chronometer. For a 10 sec beat period, a timing accuracy of 1 microsec is obtained. This corresponds to an accuracy of frequency comparison of 1 in 10^{13}. 621.317.76

OBITUARY

FRANCIS HERBERT BRAMWELL

Major Francis Herbert Bramwell, B.SC., a former director and chief engineer of the General Chemicals Division of Imperial Chemical Industries, died on the 7th May 1958, after a short illness. He was born in the Wirral on the 9th May 1890, his father being a surveyor of Customs stationed at Liverpool at that time, and educated at St. Dunstan's College, Catford, whence, in 1906, he won the Cloth Workers' open scholarship to the City and Guilds College, London, finally graduating with a first-class honours degree in mechanical and electrical engineering.

After a short practical training in the workshops of the St. Helens Colliery Co., Siddick, Cumberland, followed by a period as a draughtsman with Newton Chambers and Co., he obtained an open research scholarship and joined the National Physical Laboratory at Teddington, where he specialized on problems connected with propellers and published a number of papers. At the outbreak of the 1914–18 War he was seconded to the Air Department of the Admiralty and was engaged first on the design of large seaplanes and then moved to Felixstowe air station.

His service with I.C.I. began in 1920, when he joined Brunner Mond and Co. as a member of the pioneer team engaged on preliminary schemes for ammonia-synthesis plants. After five years at Billingham, on engineering research and later as deputy chief engineer, he was moved to Winnington as research manager and two years later, soon after the formation of I.C.I., was transferred to London.

In the early 1930's he spent a considerable time in South Africa helping African Explosives and Chemical Industries Ltd. with the design and construction of an ammonia-synthesis plant, and on completion of this work he was responsible for the design and construction of a similar plant in Czechoslovakia. Towards the end of 1938 his final transfer took place when he was appointed to the board of the General Chemicals Division as chief engineer.

Despite heart trouble, which had worried him for some time, he did not spare himself during the Second World War and with his staff was heavily involved on the design and construction of the agency factories which the Division built for the Ministry of Supply. At the end of the war the load was eased for only a short time, and the Division then started on the large post-war programme for new plants and extensions which has continued ever since.

His retirement was an active one. He had for a short time previously been appointed to the board of the Power-Gas Corporation at Stockton on Tees, and he continued to serve on this. For many years he had taken a great interest in the affairs of a number of professional institutions in London and in the activities of his old college, the City and Guilds College; and the transfer of his home from Hoylake to Banstead, while taking him away from close contact with old friends in the North-Western area, enabled him to devote more time to this interest. With his cheerful and friendly manner, Frank Bramwell had many friends, and these he valued highly. His great sense of duty, his capacity to make friends and his cheerfulness were outstanding characteristics, which, together with his very happy home and family background, about which he loved to talk, were the foundations for a full life both at work and at play.

He joined The Institution as an Associate Member in 1944 and was elected a Member in 1948. D. B. H.

HERBERT WOOLISCROFT BLADES

Herbert Wooliscroft Blades, who was born at Leek, Staffordshire, on the 29th July 1881, died in hospital in Birmingham on the 20th August 1958, after suffering ill-health for several years.

He was educated at grammar schools in Leek and Newcastle under Lyme and at technical colleges in Birmingham, Oldham, and Sheffield and at the South Western Polytechnic, London.

After serving an apprenticeship with the Butterley Coal and Iron Co., Silverdale, Staffordshire, he became an improver with the Sheffield Corporation Electricity Supply Department in 1901 and a shift engineer with the Charing Cross and Strand Electricity Corporation, London, in 1904.

He moved to Birmingham in 1906 on receiving an appointment with the Aston Manor Corporation, where he held the position of mains and substations superintendent until Aston was absorbed under the Greater Birmingham Scheme in 1911.

He served with the City of Birmingham Electricity Supply Department for 33 years; he was responsible for many technical and practical improvements and developments and occupied, with distinction, the positions of district mains engineer, district superintendent, first assistant mains engineer, and mains engineer until he retired in 1944.

Blades had a quiet and kindly disposition, which endeared him to all his colleagues and staff. He was a Freemason and a long-standing member of the Birmingham Electric Club. In his youth he was a keen cyclist, tennis player and swimmer and latterly enjoyed golf and bowls. He leaves a widow and an only son, who holds an important appointment in the electrical engineering industry in Canada. Blades's whimsical charm and warm friendship will be sorely missed by his many friends in the Midlands.

He joined The Institution as a Student in 1904 and was elected an Associate Member in 1908 and a Member in 1941. He was awarded a Premium, with A. C. MacQueen, for a paper on 'The change-over of low-tension distribution systems from direct current to alternating current', which was published in the *Journal* in 1932.

G. W. O. R.

British Nuclear Energy Conference

DETAILS of three forthcoming meetings of the British Nuclear Energy Conference are given below. Unless otherwise stated, the following particulars hold for them: they take the form of the presentation and discussion of one or more papers; they are held at 5.30 p.m., with tea at 5 p.m.; and tickets of admission are not required.

1959

JANUARY 22–23 *Thursday–Friday*

SYMPOSIUM ON NUCLEAR FUEL CYCLES

Sponsoring society: The Institute of Physics, 47 Belgrave Square, London S.W.1

Place of meeting: The Institution of Civil Engineers, 1–7 Great George Street, London S.W.1. Application forms for attendance at the symposium are obtainable from the Secretary of The Institute of Physics

Session 1 (Thursday, 2.30–5.30 p.m.)

LONG-TERM REACTIVITY CHANGES H. Rose and J. J. Syrett

THEORY OF ONCE-THROUGH FUEL CYCLES S. E. Lewis

PERTURBATIONS DUE TO FUEL CYCLES J. G. Balfour, D. L. Booth and R. S. Bulloch

Session 2 (Friday, 9.30–11.30 a.m.)

OPTIMIZATION OF FUEL CYCLES P. R. J. French and C. S. Lowthian; P. J. Grant, W. Oswald and P. D. D. Russell

Session 3 (Friday, 11.45 a.m.–1.0 p.m.)

OPERATIONAL PROBLEMS ASSOCIATED WITH FUEL CYCLING J. C. C. Stewart and N. L. Franklin

Chairman's closing remarks

JANUARY 28 *Wednesday*

Sponsoring society and place of meeting: The Institution of Electrical Engineers, Savoy Place, London W.C.2

DESIGN OF ELECTRO-MECHANICAL AUXILIARIES DIRECTLY ASSOCIATED WITH POWER-PRODUCING REACTORS A. E. Harwood, P. Scott, M.A., and B. H. Stonehouse, B.SC.(ENG.)

FEBRUARY 4 *Wednesday*

Sponsoring society: The Institute of Fuel, 1 Devonshire Street, London W.1.

Place of meeting: The Institution of Civil Engineers, 1–7 Great George Street, London S.W.1

RADIOACTIVE CORROSION PROBE D. Anson

PAPERS AND MONOGRAPHS

published individually this month

Papers accepted for reading at meetings, and monographs, are first published individually and are republished later in the Proceedings; as soon as these separates are available they are described in this feature. The papers are supplied free of charge; the price of a monograph is 2s.

In addition, reprints of papers read at meetings, including the discussions thereon, and of papers not read at meetings, become available, price 2s., within two months of their appearance in the Proceedings.

Applications, quoting the serial number of the paper, monograph or reprint, as well as the author's name, and accompanied by a remittance where appropriate, should be addressed to the Secretary. For convenience, books of five vouchers for this purpose can be obtained in advance, price 10s.

Those who obtain a copy of a paper published individually—if they do not take the Part of the Proceedings in which it will be republished—are urged to apply in due course for a reprint, as this is the final and correct version and includes the discussion.

PAPERS

Simple investigation of cross-modulation distortion arising from pulling effect in a frequency-modulated klystron *Paper* 2789 R: *Part A*

DAG T. GJESSING, B.SC.

A SIMPLE theoretical approach to the problem is given. An expression of the distortion spectrum relative to the fundamental component is derived; and, on the basis of this expression, a family of curves illustrating the severity of the distortion is computed and plotted on a logarithmic scale. Even small mismatches on the far end of a relatively short feeder from the klystron cause serious crosstalk, which, if not remedied, limits the quality of the modulator unit.

To be read on the 23rd February 1959

Theory and behaviour of helix structures for high-power pulsed travelling-wave tube *Paper* 2788 R: *Part B*

G. W. BUCKLEY, M.A., *and* J. GUNSON, B.A.

THE work is part of an investigation aimed at developing a multi-megawatt pulsed travelling-wave tube. To this end, a multi-start helix structure which may be water-cooled is considered both theoretically and experimentally.

Theoretical relationships are determined for the axial series impedance of a sheath helix surrounded by a perfectly conducting cylinder and for the phase velocity of the propagating modes. Results of experiments on four- and eight-start helix structures are found to give reasonable correspondence with the theoretical predictions for equivalent bounded sheath helices.

Date for reading not yet fixed

Selection of insulation levels and tests for high-voltage transformers *Paper* 2804: *Part A*

G. B. HARPER

THE author reviews factors influencing the selection of transformer-insulation levels, service experience associated with the British 132kV and 275kV Grid systems, and transformer-insulation tests.

A pattern for the over-all insulation strength of a transformer, relative to service conditions, is developed from examination of test procedure, insulation characteristics, variation in voltage waveform, voltage transfer to other windings, and the influence of associated apparatus. This pattern is compared with the characteristics of protective devices, and margins between insulation and protective levels are discussed. Circumstances permitting the adoption of transformer-insulation levels below those now specified are considered, suggesting that consequential capital savings for a 132kV system would be marginal but at higher voltages could be significant.

A survey is made of service experience and fault statistics for the British high-voltage networks, indicating that there would be no advantage in changing the present methods of surge protection. Experience with acceptance tests is reviewed, and suggestions are made for a possible revision of insulation-test procedure.

Date for reading not yet fixed

Discrimination between h.r.c. fuses *Paper* 2805 U: *Part A*

E. JACKS

THE author reviews the factors on which discrimination between h.r.c. fuses depends and relates these to current practice.

Consideration is given to the fundamental functions in fuse operation and the principles of system planning to facilitate discriminative protection. Suggestions are made on the presentation of data to assist in the choice of fuses.

Brief examples illustrate the conception of degree in discriminative protection.

To be read on the 12th February 1959

Multi-cavity klystron with double-tuned output circuit *Paper* 2825 R: *Part C*

H. J. CURNOW, B.SC., *and* L. E. S. MATHIAS, M.SC.

AN improved bandwidth is obtained from a six-cavity pulsed S-band klystron amplifier by the use of a double-tuned output circuit. The output power was greater than 2·5MW over a band of 6·3% when the drive power was optimized at each wavelength, and greater than 2MW over a band of 5·5% with a constant drive of 25 watts. The power in the electron beam was 10MW.

Date for reading not yet fixed

Field strengths required for reception of television in Bands I, II, IV and V *Paper* 2816 R: *Part B*

G. F. SWANN

THE author examines the factors involved in the reception of 405-line television signals in the four frequency bands assigned by international agreement to television broadcasting in the European area. After considering receiving-installation characteristics appropriate to the various bands, and the statistical variation of field strength with aerial location over the range of frequencies involved, a basis for the specification of the median field strength defining the nominal limit of the service area of a television station is described.

The estimates made, particularly for Bands IV and V, must of necessity be provisional. As and when first-hand experience of operation in these Bands becomes available, it may be necessary to modify them. Despite this limitation, however, it is considered that the figures given provide a useful interim guide for planning purposes.

To be read on the 27th April 1959

Turbogenerator performance in exceptional operating conditions *Paper* 2846: *Part A*

T. H. MASON, P. D. AYLETT, PH.D., M.SC.(ENG.), *and* F. H. BIRCH, B.SC.(ENG.)

TESTS were made to determine the performance of a normally inactive and a continuously acting turbogenerator, and some operating conditions which do not often arise in normal service were checked. Typical details are given of tests on a generator operating at large leading power factors with different excitation-control systems. Instances of instability and out-of-step running occurred and were recorded, and the machine was tested as an asynchronous generator at various slip frequencies.

A method of synchronizing, previously discussed but not tested and recorded in this country, was used, in which the running

generator was connected to the busbars and the excitation applied after a time interval. Conclusions are given.

To be read at Newcastle upon Tyne on the 26th January and in London on the 5th February 1959

MONOGRAPHS

Heaviside papers found at Paignton in 1957 *Monograph* 319

H. J. JOSEPHS

THE papers unearthed dealt mainly with problems connected with the flow of electromagnetic energy and showed that Heaviside had extended Maxwell's theory so that gravitation could be fitted in with electromagnetism.

It was also found that Heaviside had evolved a rigorous justification for his 'operation' of extracting the square root of the process of partial differentiation; for he had discovered the conditions in which his differential time operator p lost its original significance and became the transform parameter of an infinite integral of the Stieltjes type which obeys all the laws of algebra and analysis.

Filament noise source for 3 Gc/s *Monograph* 323 R

E. W. COLLINGS, M.SC., PH.D.

THE construction of an incandescent filament lamp and suitable tuned-waveguide mounting for use as a noise source at 3 Gc/s is described. Methods of measuring filament temperature are outlined, and the procedure for assessing mounting losses is described. Results of some noise measurements on a 6-watt fluorescent lamp and on some cold-cathode argon discharges are outlined.

Quadratic interpolation in tapped-potentiometer function generators *Monograph* 324 M

E. M. DEELEY, B.SC., PH.D.

A METHOD is described of obtaining quadratic interpolation in a tapped-potentiometer generator for functions of a single variable. The method depends on the quadratic form of the variation of resistance to earth at the slider, across which is developed the voltage necessary to reproduce correctly the first three terms of the Taylor's series. The supply to the tapping points from voltage sources of zero and finite resistance is analysed, and the problem of supplying these voltages is examined. The application of the method to the generation of functions of two variables is briefly discussed.

Calculation of the electric field in a sphere-gap by means of dipolar co-ordinates *Monograph* 325 M

PROF. G. W. CARTER, M.A., *and* S. C. LOH, B.SC., PH.D.

THE problem of calculating the electric field in a sphere-gap, usually attacked by means of an infinite series of image charges, is here approached through the direct solution of Laplace's equation. This solution is obtained in dipolar co-ordinates, which are suitable for problems in which boundary conditions are specified on two non-intersecting spherical surfaces. The result is given as an infinite series, from which is derived a curve, universally applicable, for the maximum voltage gradient in the field between two equal spheres. The alternative method of solution by image charges is briefly outlined for comparison.

New synthesis procedure for two-terminal-pair networks using symmetrical lattice structure *Monograph* 326 R

S. S. FORTE, B.SC., PH.D.

A NEW synthesis procedure is given for the realization of two-terminal-pair networks without ideal transformers. A new theorem is formulated on the necessary and sufficient conditions to be satisfied by a prescribed set of impedance or admittance functions for it to be realized as a symmetrical lattice network with series impedances (or shunt admittances) at either end of the structure, without ideal transformers.

A numerical example is included in the appendix to illustrate the synthesis procedure.

Contents of the current issues of the *Proceedings*

The date in italics is that of the Journal review, special article, or synopsis. Where given, the date in capitals is the month in which a paper or monograph was published individually

PART A. POWER ENGINEERING (DECEMBER 1958)

See the Journal for December 1958, p. 686

PART B. RADIO AND ELECTRONIC ENGINEERING (JANUARY 1959)

S. E. GOODALL, M.SC.(ENG.), F.Q.M.C. **Inaugural Address** *January 1959*

G. MILLINGTON, M.A., B.SC. **Radio and Telecommunication Section: Chairman's Address** *January 1959*

J. K. WEBB, M.SC.(ENG.), B.SC.TECH. **Measurement and Control Section: Chairman's Address** *January 1959*

Centre, Sub-Centre and Group Chairmen's Addresses

L. M. STEPHENSON, B.SC.(ENG.), AND PROF. H. E. M. BARLOW, PH.D., B.SC.(ENG.). PAPER 2748 R **Power measurement at 4 Gc/s by the application of the Hall effect in a semiconductor** *January 1959*

G. H. MILLARD, B.SC. PAPER 2747 R **Measurement of non-linearity in cracked-carbon resistors** *October 1958*

A. D. WILLIAMS, B.SC.(ENG.), AND D. C. GORE, B.SC.(ENG.). PAPER 2761 R **Design and performance of a new low-noise triode for use up to 1000 Mc/s** *January 1959*

A. F. HARVEY, D.PHIL., B.SC.(ENG.). PAPER 2768 R **Radio-frequency aspects of electro-nuclear accelerators** *January 1959*

A communicated discussion on **Space charge as a source of flicker effect** and **Capacitance between diode electrodes in presence of space charges**

C. W. McLEISH, M.SC., AND R. S. ROGER, B.APP.SC. PAPER 2766 R **Investigation of high-frequency direction-finding errors caused by nearby vertical reradiators** *January 1959*

A. M. THOMPSON, B.SC., AND R. W. ARCHER. PAPER 2778 M **Very precise short-period comparator for 100 kc/s frequency standards** *January 1959*

A communicated discussion on **Precision thermo-electric wattmeter for power and audio frequencies**

PART C. MONOGRAPHS (SEPTEMBER 1958)

See the Journal for September 1958, p. 519

National Lending Library for Science and Technology

THE D.S.I.R. will take over part of the former Royal Ordnance Factory at Thorp Arch, near Boston Spa, Yorkshire, for the use of the new National Lending Library for Science and Technology. Present proposals indicate that the library will begin operating at Thorp Arch in 1961 and become fully operational during 1962. It will take over the responsibility for the lending service now provided by the Science Museum Library, which in future will concentrate on serving the needs of the enlarged Imperial College of Science and Technology.

The new library will make its collection available to research, industrial, educational and other organizations by loans and photographic reproduction. Its primary objective will be to encourage the greater use of scientific and technical literature. One important activity will be the expansion of work on the translation of Russian scientific literature.

Elections and Transfers

The following elections and transfers approved by the Council are effective from the 4th December 1958

ELECTIONS *Graduates*

BALDWIN, Desmond Stanley Frederick
BARCLAY, Peter Clark
BRENNEN, Derek Henderson
BURDON, Alan Ralph, B.SC.
CANFIELD, Derek John, B.SC.(ENG.)
CATCHPOLE, Peter, B.SC.(ENG.)
FIELDS, Rowland Richard, B.SC.(ENG.)
GILBERT, Donald Morley, B.SC.(ENG.)
HENDERSON, Ronald George, B.E.
HILL, Barry Michael Ernest, B.SC.(ENG.)
HOOKE, Constant Ebenezer Knox
JONES, Bernard Samuel
LOCKLEY, Maurice John, B.SC.
MASON, Albert
NAVARATNAM, Kandiah
NEILSON, James McEwan McIntyre, B.SC.
OLIVER, John Frederick Clinton
PAPADOPOULOS, Athanasios Basileiou
PIRIE, Ian Anderson, B.SC.
PITCHER, Desmond Henry
PRATT, Thomas Patrick
RENNIE, Robert Alexander
RICE, Kenneth Martin
SCOTT, Joseph
SEWELL, Ralph Antony, B.SC.(ENG.)
SIMPSON, Robert John, B.SC.(ENG.)
SMITH, Maurice Close
STAINES, Frederick Charles
STOCK, Leslie Allen
STONE, Leslie Harold
TUBB, David Alexander
VOICE, Leslie Alfred
WADDILOVE, Ronald George
WALKER, Gilber McLellan
WILLIAMS, John Laurie, B.E.

Students

ALMOND, John Duxbury
ANDREWS, Derek Frederick
ATTWELL, Brian Ernest
BAMFORTH, Keith Vaughan
BASU, Nripendra Nath, B.SC.
BEAR, Leslie
BEGG, Alastair George
BENNETT, Lincoln Albert Mounce
BERETVAS, Thomas
BIEDERMAN, John Albert
BIRD, Kenneth Henry George
BISWAS, Dhirendra Nath, B.SC.
BORS, Gregory
BOSE, Buddha Dev, B.SC.
BOWLER, Raymond Stephen
BRANDIE, William
BROOKS, John Dominic, B.A.
BUCHAN, William Arthur
BURGESS, Brian Douglas
BURGESS, David William
BURGOYNE, Ian Morgan
CAMPBELL, John Roy
CARNE, Christopher Michael
CARTER, Alexander
CHAKRAVARTI, Prasun Kumar, B.SC.
CHALLIS, Michael Jeremy
CHAPMAN, Cyril Ernest
CHATURVEDI, Dinesh Chandra, B.SC.
CHRISTIE, Ian
CLEWS, Dudley Ernest, B.A.
CLULEY, Brian Herbert
COGGER, Brian David Charles
COLDWELL, John Keith
COMBER, Christopher Edward
CONWAY, James Peter
COOKE, Maurice
CORREA, Oswald Wilson
COTTELL, Richard George Edward
COWLING, Peter
CRANSHAW, Arthur James
CRUICKSHANK, James McNicol
CUNLIFFE, Juan Craine
DALY, Peter
DAVIDSON, James Ian
DAVIS, William Grant
DAWES, Alan James
DAYAL, Mohan
DENTON, Anthony Jon
DEVINE, Trevor James
DIXON, Neil
DOE, Eric Nolan
DONEY, Ronald William
DOWLING, Daniel Pettitt
D'SA, Edgar Benedict
DUNBAR, Robin Malcolm
DYKES, John Leo
ENTWISTLE, Richard
EVANS, Leonard
EWING, Douglas Kyles
FARRELL, Patrick
FARRINGTON, Derek
FERNANDES, Albert Joe Francis
FISHER, Peter Robin
FISHER, Ronald John
FLANDERS, Vivian Maurice, B.SC.
FLYNN, John Philip
FOK, Tai Loy
FOOT, Michael John
FORD, George
FORSTER, Brian Michael
FOX, David John Charles
FREMONT, David de Mouilpied
FRENCH, John Edwin
FYFE, Robert Lendrum, B.SC.
GALE, Brian John
GILDER, John, B.SC.
GLADSTONE, Edward Woodward
GLEDSON, Richard Michael
GNANASABESAN, Subramaniam, B.SC.
GODFREY, David
GRACIAS, Raymond Justinho
GRUNDY, Alec
HAND, Geoffrey
HARDING, Robert Harold
HARNETT, Herbert Martin
HARRIS, Brian Michael David
HARVEY, Robert Pearce
HASTIE, Michael John
HAWKINS, Kenneth Arnold
HAYES, James Barry
HEITON, John Raymond
HELLIWELL, Alan James
HILLING, Anthony Edward
HOLLIS, James Edward Laurie
HOOK, George William
HORSFIELD, Michael
HUDDLESTONE, Bernard Frank
HUMPHRIES, Brian Anthony
HUNTER, Ian McGregor, B.SC.
IONIDES, Rudolf
ISAAC, Arthur Edward
JACOVIDES, Linos Jacovou
JEBSON, Derek
JEFFERY, Alan
JOHNSON, Roger Christopher Howard
JOHNSTON, David Lawrence
JOHNSTON-SMITH, Christopher Barry
JONES, Royston
JOYCE, Anthony
KASINATHAN, Subramaniam
LAMBERT, Terence William
LANGSTONE, Peter George
LAVENDER, Anthony William
LAWRENCE, Colin Frederick
LAYSON, David John, B.SC.
LEE, Bryan David
LEE, David Alan, B.SC.
MACCURRIE, David Robert
MACDONALD, Malcolm Hugh, B.SC.
MCGOUGH, John Charles
MALLIA, Frankie
MANNING, Bryan Robert Merer
MANNING, Robert John
MANNS, Phillip David
MASTERS, Kenneth William
MATTHEWS, John Errol, B.SC.
METCALF, John Hugh
MILLAR, Robert Mathieson Gemmell
MILTON, Robert Leonard
MITHA, Sadruddin Hasham
MONTGOMERY, George Richardson
MOONEY, Roy Marshall
MOORE, Raymond Frank
MORGAN, David
MORGAN, Thomas Dilwyn
MORRIS, William Arthur
MORSE, John Robert Drake
MORTON, John Wilfrid
MOYERS, Vernon, jun.
MOYES, Andrew
MYERS, David Leslie
NEVELL, Ian James
NEWMAN, Allan Frederick
NEWMARCH, Derek Charles
NICOL, Leslie McKenzie
ORR, Alan Halyburton, B.SC.
O'SHEA, Brian Desmond Anthony
OVENDEN, William John Samuel
OVERY, Edward David
PALMER, Brian William
PARK, Michael Frederick
PHILLIPS, Gareth Eifion
PIERCE, Reginald Roy
PILBIN, Brian
PILLINGER, Kenneth John
PRICE, John Eric, B.SC.
RAHMAN, Ahmad Nazar Abdul
RAM, Amolak
RAY, Biswa Nath, B.SC.
REED, Donald Brian
REID, James
RITCHIE, Peter William
ROBERTSON, Philip Pearson
ROLFE, Patrick James
ROTHWELL, Ronald
ROWNTREE, James
RUMBALL, Edward Ian
RUSSELL, Tarbet Chalmers, B.SC.
SAHNEY, Ravish Kumar
SEDGWICK, Anthony
SENGUPTA, Amit
SHARPLEY, William Barry
SHAW, Robert William
SHERRATT, Philip James
SHOTTON, John
SIMM, Brian William
SIMMONS, Derek Brian
SIMPSON, Ronald Reid Selbie
SINGH, Satish Chandra, B.SC.
SONES, James Harold
SPELLER, John Philip
STEELE, Derek Herbert
STEVENS, John, B.SC.
STOLLARD, Brian
STONE, Roger Louis
STRANGEWAYS, Ian Watson
SUNLEY, Richard William
TAN, Kim Chew
TAYLER, Brian Horace Everard
TAYLOR, John Owen
THOMPSON, David
TODD, Robert John
TSANG, Hin Wa Albert
TYACKE, John Nicholas
UNDERWOOD, Justin Dowsett
VAUGHAN, Peter Arthur
WEBB, Leonard Victor
WEBBER, John
WEBBER, John George
WEDLAKE, David
WESTON, Anthony Ashby
WHALLEY, Anthony
WHITAKER, George David, B.SC.
WHITING, Barry Rex Antony
WIELE, Neville Hermann Joseph
WIJERATNE, Warusahennedige Vineethewansa Vijaya Soysa
WILLIAMS, Roger David, B.SC.
WILSON, Robert Alan, B.SC.
WRIGHT, Ronald Henry
YOUNG, Brian Guy
YOUNG, Peter Grafton Craig, B.SC.

TRANSFERS *Student to Graduate*

ALEXANDER, Ian Robert
ANWAR, Mohammad, B.SC., B.SC.(ENG.)
AUSTIN, Veyne Noel
AZIZ, Faik Mohammed Abdul, B.SC.
BEHENNA, Norman Wilfred, DIP.TECH.(ENG.)
BELCHER, Peter Louis, B.SC.(ENG.)
CARPENTER, Reginald Peter
CLOUGHLEY, Robert James
DANIELS, Arthur Richard, M.SC.
DOWLING, John Blair
DRUCE, David Brian, DIP.TECH.(ENG.)
DUNSBEE, John, B.SC.
ENO, Offiong Obong
FINNEY, David, DIP.TECH.(ENG.)
FRAZER, Derek Clark
FROOME, David Sweetland, B.SC.(ENG.)
GASKELL, William Napier
GAYLER, Anthony Samuel
GOULDEN, Derrick Alastair
GRAY, George William Peter
GREEN, John Owen
HARRINGTON, Kenneth Edward
HEALD, John Gordon
HEELIS, James Baxendale Guthrie, DIP.TECH.(ENG.)
HEYLEN, Albert Ernest Desiree, B.SC.(ENG.), PH.D.
HOOKHAM, Michael George
HOWE, Derek
JONES, Lt. Gwilym Martin, B.SC.(ENG.)
LOCKWOOD, Edward Foster, B.SC.
LODGE, Alec John, B.SC.(ENG.)
MOFFETT, Austin, B.SC.
MOON, Rudolph John, B.SC.
MORRIS, Alan
MORRIS, Brian Taylor Jordan, B.SC.
OYEBOLU, Philip Bolude, B.SC.
PATCHETT, Bernard John, DIP.TECH.(ENG.)
PILCHER, Derek Gerald, B.SC.(ENG.)
PILLING, Oliver Jackson, B.SC.TECH.
REARDON, Bernard Charles, B.E.
REGAN, Anthony, B.SC.
RICHARDSON, John Robert, B.SC., PH.D.
RICHARDSON, Robert
ROSSITER, Brian
ROWE, Richard William, B.SC.(ENG.)
THOMPSON, Neil Arthur
TOPPING, Trevor Rex
WEBBER, Samuel Thomas
WELLS, Peter Neil Temple, DIP.TECH.(ENG.)
WILKES, Colin Edward, B.SC.(ENG.)

District Meetings

ARRANGEMENTS for District Meetings in January and February other than those in the area of a Local Centre

January 1959

19 READING (at the George Hotel, King Street, at 7.15 p.m.)
Monday E. J. SUTTON 'National Inspection Council—two years' operation'

21 OXFORD (at the S.E.B., 37 George Street, at 7.0 p.m.)
Wednesday S. C. DINENAGE 'Development of off-peak heating with particular reference to floor warming'

February 1959

2 MAIDSTONE (at the Technical College, at 6.30 for 7 p.m.)
Monday E. P. BENTHAM 'Electric control of stage and television lighting'

ANNOUNCEMENTS TO MEMBERS

THE HOMES FUND

SUMMARY OF CONTRIBUTIONS RECEIVED TO 19TH DECEMBER 1958

	No. of Contributors	£	*s.*	*d.*
£1000 and over	6	6000	0	0
£100 to <£1000	30	6586	3	0
£5 to <£100	868	9190	9	5
£2 to <£5	2085	5732	17	5
under £2	24224	12661	1	5
		£40170	11	3

APPOINTMENTS AND NOMINATIONS

WIRING REGULATIONS COMMITTEE

ON the nomination of the Electrical Contractors' Association Incorporated, the Council have appointed Mr. C. King, MEMBER, to serve on the above Committee in place of Mr. R. A. Marryat, B.SC.(ENG.), MEMBER, who is now serving *ex officio* as the Chairman of the Utilization Section.

B.S.I. SUB-COMMITTEE ELE/32/14—RADIO INTERFERENCE FROM POWER LINES AND ASSOCIATED PLANT

The Council have nominated Dr. J. S. Forrest, M.A., MEMBER, to serve as their representative on the above Sub-Committee.

PROPOSED B.S.I. COMMITTEE ON INPUT AND OUTPUT STANDARDS FOR DATA-PROCESSING EQUIPMENT

The Council have nominated Mr. R. H. Tizard, B.A., MEMBER, to serve as their representative on the above Committee.

CODE DRAFTING COMMITTEE FOR DUST-TIGHT ELECTRICAL EQUIPMENT (ELCP/27)

The Council have nominated Mr. J. W. Binns, MEMBER, to serve as their representative on the above Code Drafting Committee.

EAST ANGLIAN REGIONAL ADVISORY COUNCIL FOR FURTHER EDUCATION—EASTERN AREA ENGINEERING SUB-COMMITTEE

The Council have nominated Mr. J. A. Sumner, MEMBER, to serve as their representative on the above Sub-Committee.

EAST ANGLIAN REGIONAL ADVISORY COUNCIL FOR FURTHER EDUCATION—WESTERN AREA ENGINEERING SUB-COMMITTEE

The Council have nominated Capt. N. Hiller, B.SC.(ENG.), ASSOCIATE MEMBER, to serve as their representative on the above Sub-Committee.

SWANSEA TECHNICAL COLLEGE—ADVISORY COMMITTEE FOR ENGINEERING

The Council have nominated Mr. T. Gill, B.SC., ASSOCIATE MEMBER, to serve as their representative on the above Committee.

COURT OF THE UNIVERSITY OF BRISTOL

The Council have nominated Mr. A. N. Irens, MEMBER, to serve as their representative on the above Court.

ENGINEERING INSTITUTIONS' EXAMINATION, PART I, COMMITTEE

The Council have nominated Mr. L. H. A. Carr, M.SC.TECH., MEMBER, Prof. E. Bradshaw, M.B.E., M.SC.TECH., PH.D., MEMBER, and Mr. A. H. Mumford, O.B.E., B.SC.(ENG.), MEMBER, to serve as their representatives on the above Committee.

ENGINEERING JOINT EXAMINATION BOARD

The Council have nominated Mr. L. H. A. Carr, M.SC.TECH., MEMBER, and Prof. H. E. M. Barlow, PH.D., B.SC.(ENG.), MEMBER, to serve as their representatives on the above Board.

JOINT COMMITTEE FOR NATIONAL CERTIFICATES (ENGLAND AND WALES)

The Council have nominated Prof. M. W. Humphrey Davies, M.SC., MEMBER, Mr. G. S. C. Lucas, O.B.E., MEMBER, and Mr. E. R. L. Lewis, M.A., ASSOCIATE MEMBER, to serve as their representatives on the above Committee.

JOINT COMMITTEE FOR NATIONAL CERTIFICATES (SCOTLAND)

The Council have nominated Prof. B. Hague, D.SC., PH.D., MEMBER, Mr. W. B. Laing, MEMBER, Prof. M. G. Say, M.SC., PH.D., F.R.S.E., MEMBER, and Mr. J. Stewart, M.A., B.SC., ASSOCIATE MEMBER, to serve as their representatives on the above Committee.

JOINT COMMITTEE FOR NATIONAL CERTIFICATES (NORTHERN IRELAND)

The Council have nominated Prof. T. P. Allen, M.SC., MEMBER, Mr. J. R. W. Murland, B.SC.(ENG.), MEMBER, and Mr. T. S. Wylie, MEMBER, to serve as their representatives on the above Committee.

B.S.I. TECHNICAL COMMITTEE ACM/9—MEDICAL ULTRASONIC EQUIPMENT

The Council have nominated Dr. C. N. Smyth, M.A., B.SC.(ENG.), B.M., B.CH., MEMBER, to serve as their representative on the above Committee.

OVERSEA REPRESENTATIVES

The Council have appointed Mr. H. D. Furber, ASSOCIATE MEMBER, as their Oversea Representative for the Near East; Mr. H. W. Stubbs, M.C., MEMBER, as their Deputy Oversea Representative for Malaya and Singapore; and Mr. J. M. Stock, O.B.E., M.ENG., MEMBER, as their Deputy Oversea Representative in Uganda.

PROGRAMME OF MEETINGS

THE programme card of London Meetings for the second half of the 1958–59 Session is being sent with this issue of the *Journal* to all members not residing within the area of a Local Centre or Sub-Centre.

Any member living in the provinces who often visits London, and is thus able to attend London Meetings, may obtain a copy of the card on application to the Secretary.

MEMBERS TRAVELLING TO AND FROM THE UNITED KINGDOM

MEMBERS visiting or taking up residence in the areas of any of the Oversea Branches, Oversea Committees or Joint Oversea Groups, which are listed on pp. 62 and 63, are invited to apply to the Secretary of The Institution for a letter of introduction to the appropriate Honorary Secretary.

The Secretary will be obliged if members coming home from oversea will inform him of their addresses in this country, even if they do not desire a change of address to be recorded in the Institution register. This will enable him to send them information about the various meetings etc. of The Institution and its Local Centres and, when occasion arises, to put them in touch with other members.

The Secretary will be glad if members from oversea who are able to visit the Institution premises will call on him.

INTERNATIONAL FEDERATION OF AUTOMATIC CONTROL

THE first International Congress of the International Federation of Automatic Control is to be held in Moscow from the 25th June to the 5th July 1960. The British Conference on Automation and Computation have been asked by the Executive Council of the International Federation of Automatic Control for their co-operation in arranging for the submission of papers for the Congress from British sources; and, in accordance with this request, the British contribution to the Congress will be co-ordinated through the General Committee of the British Conference on Automation and Computation, with the assistance of its three Groups.

The Congress will cover these three fields:

Section 1 Theoretical and experimental investigations on automatic control and servomechanisms

Section 2 Instrumentation and investigations connected with the development of automatic-control systems

Section 3 Industrial applications of automatic control (including the application of prediction and computing devices).

The Congress will include: (a) the presentation and discussion of scientific reports, (b) excursions to scientific institutions and also to various automatic undertakings, and (c) visits to centres of culture in Moscow.

Intending authors should submit abstracts of their proposed papers, not exceeding 500 words in length, and not later than the 1st February 1959, to Mr. W. Bamford, Honorary Secretary, Group B, British Conference on Automation and Computation, c/o The Institution of Electrical Engineers, Savoy Place, London W.C.2.

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We reserve the right to withdraw this declaration.

1959 ELECTRONIC COMPONENTS CONFERENCE

THE Benjamin Franklin Hotel, Philadelphia, Pa., is the venue of an Electronic Components Conference from the 6th to 8th May 1959.

Sponsored by the Institute of Radio Engineers, the Electronic Industries Association, the American Institute of Electrical Engineers, and the West Coast Electronic Manufacturers Association, the Conference will include papers on these subjects: components in space vehicles; 'microminiaturization'; the mechanism of failure; transistors; control devices; passive components; and radiation effects.

Further information is available from Bernard F. Osbahr, *Electronic Industries*, Chestnut and 56th Streets, Philadelphia 39, Pa., U.S.A.

CONVENTION ON STEREOPHONIC SOUND RECORDING, REPRODUCTION AND BROADCASTING

WITH the approval of the Council, the Committee of the Radio and Telecommunication Section have arranged a Convention on Stereophonic Sound Recording, Reproduction and Broadcasting. It will be held in the Institution building on the 19th and 20th March 1959. Sessions will cover basic principles; stereophonic recording on film, tape and disc; and stereophonic broadcasting techniques.

Registration forms and further particulars are obtainable from the Secretary.

SCIENCE MUSEUM LIBRARY: PHOTOPRINT SERVICE

UNDER the terms of the Royal Society's Declaration on Fair Copying (see p. 48) and the Copyright Act, 1956, the Science Museum Library is permitted to supply photoprints of articles from many of the periodicals it holds. The charge is 5s. for each article requiring not more than five photographs (a maximum of 10 consecutive pages). Longer articles cost 5s. for each 10 pages or fraction thereof.

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No remittance should be sent until an invoice has been received from The Institution.

Members may like to be reminded that reprints of many recent papers published in the *Proceedings* are available on request from the Secretary at a price of 2s. per reprint (see p. 44).

ESSAY PRIZE COMPETITION

AN Open Competition and a Student Competition for essays on variety reduction are sponsored by the British Productivity Council.

For the open competition, the essay should present original thinking on variety reduction, should be not more than 10000 words, and should be in a form suitable for a public lecture. A prize of up to 150 guineas will be awarded.

For the student competition, not more than 5000 words are required. A prize of 15 guineas is offered.

Essays should reach the British Productivity Council, 21 Tothill Street, London S.W.1, by the 30th April 1959 for the student competition and by the 31st July 1959 for the open competition.

RADIO SHOW 1959

IT is announced that the 26th national radio and television exhibition will be held at Earl's Court, London, from Wednesday, the 26th August, to Saturday, the 5th September 1959.

Forthcoming Events at Savoy Place

ALL meetings are held at Savoy Place, beginning at 5.30 p.m. (tea at 5 p.m.), except where otherwise stated. The nature of the meeting is indicated by the following key:

E	EDUCATION DISCUSSION CIRCLE	I	INFORMAL MEETING
M	MEASUREMENT AND CONTROL SECTION	O	ORDINARY
MED	MEDICAL ELECTRONICS DISCUSSION GROUP	S	SUPPLY SECTION
R	RADIO AND TELECOMMUNICATION SECTION	U	UTILIZATION SECTION

After each paper that has now been published is added the month when a synopsis appeared in the *Journal*.

January 1959

R **19** *Monday* A. H. W. BECK, B.SC.(ENG.) 'High-current-density thermionic emitters' (Paper 2750 R) *synopsis:* November 1958

M **20** *Tuesday* K. KANDIAH, M.A., will open a discussion on 'D.C. amplifiers'†

R **21** *Wednesday* C. G. GARTON. Lecture on 'Dielectric materials—trends and prospects'†

O **22** *Thursday* D. A. BARRON, M.SC. 'Subscriber trunk dialling' (Paper 2795 R) *synopsis:* November 1958

26 *Monday* H. A. THOMAS, D.SC. The Faraday Lecture: 'Automation'‡ (at the Royal Festival Hall, London, at 6 p.m.; admission by ticket only; all tickets have been issued)

S **28** *Wednesday* (in conjunction with the British Nuclear Energy Conference) A. E. HARWOOD, P. SCOTT, M.A., *and* B. H. STONEHOUSE B.SC.(ENG.) 'Design of electro-mechanical auxiliaries directly associated with power-producing reactors' (Paper 2812 S) *synopsis:* December 1958

R **29–30** *Thursday–Friday* Convention on 'Long-distance transmission by waveguide' (all wishing to attend are required to register; full details and registration form obtainable from the Secretary)

February 1959

M **3** *Tuesday* PROF. L. S. PALMER, D.SC., PH.D. 'Examples of geoelectric surveys' (Paper 2791 M) *synopsis:* December 1958

O **5** *Thursday* T. H. MASON, P. D. AYLETT, PH.D., M.SC.(ENG.), *and* F. H. BIRCH, B.SC.(ENG.) 'Turbogenerator performance in exceptional operating conditions' (Paper 2846 S) *synopsis:* see p. 44

MED **6** *Friday* DR. P. BAUWENS, M.R.C.S., M.R.C.P., *and* P. STYLES will open a discussion on 'Problems of storing transient phenomena for subsequent analysis'* (at 6 p.m., tea at 5.30 p.m.)

I **9** *Monday* J. K. WEBB, M.SC.(ENG.), B.SC.TECH., will open a discussion on 'Discrimination and assimilation of technical literature—a growing problem'*

RM **10** *Tuesday* Joint Dinner-Dance (at the Café Royal, at 7 for 7.30 p.m.)

U **12** *Thursday* E. JACKS 'Discrimination between h.r.c. fuses' (Paper 2805 U) *synopsis:* see p. 44

E **13** *Friday* PROF. M. G. SAY, PH.D., M.SC., F.R.S.E., will open a discussion on 'Some reasons for failure in the Part III Examination'* (at 6 p.m., tea at 5.30 p.m.)

M **16–17** *Monday–Tuesday* Specialist discussion meetings on 'New digital-computer techniques' (all wishing to attend must register; form available on application)

R **18** *Wednesday* C. N. SMYTH, M.A., B.SC.(ENG.), M.B., B.CH., *and* J. SAYERS. Lecture on 'Ultrasonic iconoscopes'†

R **23** *Monday* D. T. GJESSING, B.SC., 'Simple investigation of cross-modulation distortion arising from pulling effect in a frequency-modulated klystron' (Paper 2789 R) *synopsis:* see p. 44

G. W. BUCKLEY, M.A., *and* J. GUNSON, B.A. 'Theory and behaviour of helix structures for high-power pulsed travelling-wave tube' (Paper 2788 R) *synopsis:* see p. 44

H. J. CURNOW, B.SC., *and* L. E. S. MATHIAS, M.SC.' Multi-cavity klystron with double-tuned output circuit' (Paper 2825 R) *synopsis:* see p. 44

F. H. JAMES 'Method for the measurement of very high Q-factors of electromagnetic resonators' (Paper 2847 R)

S **25** *Wednesday* F. S. FAY, M.A., J. A. THOMAS, B.SC., D. LEGG, B.SC., *and* J. S. MORTON, B.SC. 'Development of high-voltage air-break circuit-breakers with insulated-steel-plate arc chutes' (Paper 2746 S) *synopsis:* December 1958

* No advance information will be available, and no Press report will be permitted
† An abstract will be available in advance
‡ No advance information will be available

BULLETIN OF THE SECTIONS

MEASUREMENT AND CONTROL

Annual Dinner

THE Section Dinner was held on the 11th November 1958 at the Café Royal, London, where 275 members and their guests spent a most enjoyable evening.

After cocktails and an excellent dinner, the President, Mr. S. E. Goodall, in a speech enlivened with some amusing stories appropriate to such occasions, remarked that he was himself a member of the Measurement and Control Section, which was the second oldest of the four specialized Sections. He referred to the introduction in the *Journal* of the articles entitled 'The four pillars of The Institution'; the spotlight, he said, would be focused on the history of the Measurement and Control Section in the next issue (December, p. 660). It gave him great pleasure to see so many Past-Chairmen of the Section present, in particular Dr. G. A. V. Sowter and Prof. J. T. McGregor-Morris. In proposing the toast of 'The Measurement and Control Section' he was happy to associate with it the name of the present Chairman, Mr. J. K. Webb.

In his reply, Mr. J. K. Webb welcomed the President on behalf of the Section and thanked him for his kind remarks. He went on to say that although the Measurement and Control Section was numerically the smallest of the four specialized Sections, the quality and importance of its work should not be underestimated. Mr. Webb said that it gave him great pleasure to welcome the representatives of the other specialized Sections, including Mr. G. Millington, Chairman of the Radio and Telecommunication Section, Mr. D. P. Sayers, Chairman of the Supply Section, and Mr. T. E. Houghton, Vice-Chairman of the Utilization Section. He was glad to see that the Secretary, Mr. W. K. Brasher, was also able to be with them that evening. Mr. Brasher had the onerous task of keeping all four Sections in tow.

Mr. Webb warmly welcomed Mr. J. Mendelson, Chairman of the South-East Scotland Sub-Centre and two visitors from the United States—Prof. Warren McCulloch, M.D., Laboratories of Electronics, Massachusetts Institute of Technology, and Mr. A. E. Cohen, Chief of the Radiac Section, Atomic Branch, U.S. Army Signal Research and Development Laboratory.

In his concluding remarks Mr. Webb said that the Section were greatly honoured that evening to have, as their principal guest, Brig. Sir Lionel H. Harris, K.B.E., T.D., who, in addition to being Engineer-in-Chief of the Post Office, had also a distinguished war record and had recently published his autobiography under the appropriate title of 'Signal venture'. Mr. Webb then proposed the toast of 'Our Guests', linking with it the name of Brig. Sir Lionel H. Harris.

Replying, Sir Lionel remarked that he was privileged and pleased to have the opportunity of speaking on behalf of such a distinguished gathering of guests. While he regretted that, because his career had led him into so many out-of-the-way places, he had been a rather detached member of The Institution, he nevertheless recognized the importance of the work carried out by the Measurement and Control Section. It could make a very significant contribution in helping to determine the shape of things to come. As a telecommunication engineer he was at present actively concerned with the subject of data transmission and error correction, which was becoming closely allied to that of digital-computer techniques, in which the Section held a vital interest. Sir Lionel's speech was enlivened with much wit, maintaining the friendly and informal atmosphere of the occasion.

Following the speeches, we were entertained by Mr. Jimmy Rogers, a magician who, if he could not 'call spirits from the vasty deep', could at least conjure doves out of thin air with apparent ease. His performance was much appreciated.

Members and guests then forgathered and formed small groups in the lounge, where old friendships were renewed and introductions were made. It was generally agreed that a good time had been had by all.

Discussion on electronic control of machine tools

On the 28th October the Section held a discussion meeting on 'Electronic control of machine tools', a popular subject of great topical interest, which attracted a very full meeting. The opening, and principal, speaker was Mr. D. T. N. Williamson, who has been responsible for development of the Ferranti system.

The first part of his address was devoted to discussion of the economic situation as it affected methods of production, with particular reference to the position of this country with its comparatively small home market and its dependence on export trade. Mass-production techniques as hitherto understood are not appropriate to this situation, but the advent of the electronically controlled machine-tool has made possible small-quantity production at a cost comparable with mass production.

He suggested that the soundest approach was to make the servo drives on the machine tool as simple as possible and not to include any part of the programming or interpolating in their functions; this means that the use of an electronic computer is a necessary stage between the design office and the control information for the machine.

With the large-scale introduction of electronically controlled machine-tools he foresaw the position where the shop-floor employees would represent only a few per cent of the total staff in a factory; development effort should then be concentrated on reducing the remainder, who were engaged mostly in information handling and data-processing.

Finally, he suggested that discussion on the design details of such machines, as for instance whether it was better to use analogue or digital methods, was not profitable, since to the user it was the results that mattered, not how they were achieved.

A lively discussion followed. A number of people actively engaged in this field spoke, and it became apparent that requirements, as well as ideas for fulfilling them, may differ very widely.

For instance, it was pointed out that most ordinary engineering design is based on shapes made entirely from straight lines and circles and that electronically controlled machine-tools restricted to such shapes may use techniques very

different from those necessary in a machine capable of producing any form of profile. They may consequently be cheaper and not require the services of an electronic computer. Altogether the meeting was enjoyable and instructive, and thanks are due to Mr. Williamson for his carefully prepared introduction and to the other experts in the field who gave the benefit of their own experience and ideas. R. H. T.

Transistors on trial

Two papers concerning digital-computer components were read at the meeting on the 4th November 1958, when Mr. J. K. Webb took the chair.

The first paper, on 'Operational experience with a transistor digital computer', by Mr. R. C. M. Barnes and Dr. J. H. Stephen, gave a useful account of a year's operation of a small laboratory computer which uses 400 transistors, 324 of the point-contact type, as its only active elements. This paper, which was welcomed as the first self-critical analysis of a transistor computer's service performance, is reviewed on p. 33.

The machine, now known as Cadet, made its first (anonymous) appearance before The Institution during the Convention on Digital-Computing Techniques in 1956. Its construction was started in 1954, partly as an exercise in transistor-circuit design, with the objects of providing both a useful computer, needing little attendance, and the then much-needed data on transistor reliability. A magnetic drum provides a working store of 410 words and a main store of 16384 words.

Being operated without attention for 75% of the time presented special problems, for, as Mr. Barnes wryly commented, an intermittent fault was more likely to occur when no one was at hand to investigate. A spare portion of a track on the drum was used to record instructions as they were read and executed, so that when an intermittent fault caused an alarm circuit to shut down the computer a record of the last few instructions was preserved.

Considering that Cadet used point-contact transistors, which were notoriously less reliable than the junction type, Mr. Barnes felt that its service performance was a very good omen for digital computers using only junction transistors.

The subject shifted from a statistical to a logical plane when Mr. D. Eldridge introduced a new 'building brick' for a digital computer. The core logical element described in his paper 'A new high-speed digital technique for computer use' comprises one square-loop ferrite core, one transistor (used as a switch), three diodes and one resistor. The paper is reviewed on p. 32.

Mr. Eldridge said that magnetic logic had been likened to a ballot, in which the majority wins; but that was not strictly accurate since the contestants could not decide the direction of their vote, only whether they would vote or not; nor did a tie mean a recount.

He modestly apologized for the large number of components used in his unit but considered that the resulting high speed and logical flexibility gave adequate compensation. The technique differs from earlier methods in that the current required to set the core to the '1' state is obtained from a common supply and not from the previous stage. The system needs only two low-direct-voltage supplies and is tolerant of voltage and component variations, operating reliably at digit rates of 500kc/s.

The discussion was opened by Dr. G. B. B. Chaplin, who congratulated all three authors on the clarity of their papers. Referring to the transistor digital computer, he remarked that figures of over 90% availability for two of the months in service certainly proved that point-contact transistors, despite their reputed alarming failure rates, were much more reliable than valves.

In Mr. Eldridge's circuit, Dr. Chaplin had noticed that the outputs taken during reset periods could be very large and asked whether it would be feasible to duplicate circuits so that outputs were taken only during the set period or when maximum power was available. He also asked how many windings it was possible to connect in series and still obtain a sensible output.

The refreshingly honest account of Cadet's performance prompted Dr. R. L. Grimsdale to present figures relating to the 'very thin' computer, using 200 point-contact transistors, at Manchester University. He considered that it might well have paid manufacturers to do more work on point-contact transistors.

Mr. R. Williams commented on the large number of core logical devices which have appeared during the last eight years and suggested that they should be classified according to their respective merits and demerits. A satisfied user of Mr. Eldridge's unit mentioned that he had employed 50 of them in building a machine with serial *a-b-c-d* transmission.

Mr. Barnes, in an adequate and enthusiastic reply, conjured up a slide showing Cadet's performance record extended to the autumn of 1958. Over 98% availability was achieved in the last month. Although they had developed a substitute circuit, using junction transistors, as an insurance, the present failure rate was so low that they were still able to find a few usable point-contact ones.

In reply to Dr. Chaplin, Mr. Eldridge said that the number of windings connected in series was mostly limited by the tolerance on the output voltage but also by the resistance of the windings themselves and the large transitory output current necessary to cut the transistors off. He agreed with Mr. Williams that the only way to assess analogue logic and compare it with diode logic was to try it. The problem was to find someone clever enough to make the comparison.

The Chairman remarked on the amount of energy and ingenuity used by designers of logical units in circumventing the deficiencies of materials and components. Point-contact transistors, he considered, despite the pious hopes expressed during the evening, were definitely on their way out. Nevertheless, the paper presented by Mr. Barnes and Dr. Stephen was of very great interest and would provide a datum by which future improvements could be assessed.

A vote of thanks, moved by the Chairman, brought the meeting to a close.

Ferroelectrics

The Measurement and Control Section, being free to discuss whatever can be (electrically) controlled or measured, has a wide field of activity. On the 18th November, with Mr. J. K. Webb in the chair, ferroelectrics were introduced by Mr. L. A. Thomas. The subject may sound a shade esoteric to the 'heavy' engineer, and at one point the lecturer did confess to being a physicist, answering a chemist, at a meeting for engineers. Many members of the Section, however, conspire at this mixing of breeds.

For the non-physical, Mr. Thomas defined ferroelectrics as 'dielectrics having a spontaneous reversible electric polarization', so making the matter quite clear. If the analogy is not pushed too far into atomic details, where it breaks down, a ferroelectric has the same relation to an electric

field as a ferromagnetic like iron to a magnetic one. It has high permittivity (thousands in place of the usual three or four), shows hysteresis between field and polarization, and has spontaneously electrified domains of reversible polarity. Also, like a ferromagnetic, it has a Curie temperature above which it becomes para-electric, and a coercive field strength.

Mr. Thomas traced the history of these materials, from Rochelle salt known since 1921, through barium titanate discovered about 1940, to many substances revealed in the last five years. These pass under such endearing names as sodium niobate, glycine sulphate, and even guanidine-aluminium-sulphate hexahydrate, hypocoristically known as 'gash'. The lecture showed that the names do not preclude practical uses, most obviously as high-permittivity ceramic dielectrics in capacitors. Limitations are capacitance changes with voltage and temperature, and a rather high loss angle. In barium titanate, additions of Sr, Zr, Pb, Ca, Bi or other metals can be used to give better characteristics.

Since all ferroelectrics are piezo-electric, and usually strongly so, they can be used to link electric fields with mechanical movement. Major applications are in acoustic pick-ups and ultrasonic generators or detectors. Other uses include accelerometers, vibration analysers, delay lines and filter elements.

Mr. Thomas described the properties of single ferroelectric crystals, including barium titanate, glycine sulphate and 'gash', which can have such well defined rectangular hysteresis loops that they may operate, like ferrites, as switching and memory devices. Practical troubles remain to be overcome in these uses, notably change of switching time with field strength and a distressing loss of memory which afflicts some materials and is not yet fully understood.

In the subsequent discussion, Dr. L. E. Cross criticized attempts to explain dependence of coercive field on crystal thickness by surface layers with special properties. Since various experimenters required different properties, the hypothesis was not convincing. He tentatively suggested that the growth of domain nuclei with reversed polarity depends on field concentration at the ends of the nuclei, which are known to be pointed. Mr. Thomas thought this plausible.

Mr. J. M. Herbert stressed the difficulty of obtaining consistent ferroelectric properties, illustrating the point with data showing the very different effects of iron introduced into barium titanate by three alternative methods. He felt that one essential of a good ferroelectric material for capacitors was that it should not be ferroelectric.

The discussion returned to the perplexing question of amnesia in barium titanate. Mr. D. S. Campbell had found that it is absent with sinusoidal pulses; that when it does occur the domain pattern is characteristically altered; and that spontaneous recovery may take place. He thought the effect a bulk property but could offer no explanation, and the lecturer confessed himself equally at a loss.

Mr. C. F. Oxbrow presented data on 'gash' showing that the ferroelectric coercive field is less well defined than the ferromagnetic one, since it varies with the applied frequency. He thought glycine sulphate suffered less from loss of memory than barium. Another speaker had found that the hysteresis loop even of glycine sulphate changed with time. Speculations on the cause of this included loss of water of crystallization, which Mr. Oxbrow thought improbable, since this crystal is anhydrous.

The desire of several speakers to use ferroelectrics for power capacitors aroused discussion on the poor electric strength of all such materials. Mr. C. G. Garton thought this might be due, in the metal oxides, to electrolytic transport of oxygen out of the structure, leaving the material a semiconductor, owing to anion vacancies in the lattice. Single crystals of titania certainly behaved in this way.

After the Chairman had summed up with the statement that ferroelectrics, compared with ferrites, were fickle substances needing much more investigation, the meeting ended with sincere and well-earned thanks to Mr. Thomas. C. G. G.

RADIO AND TELECOMMUNICATION

How good is your telephone?

AT the meeting on the 27th October 1958, the Chairman, Mr. R. J. Halsey, pointed out that this was the first of the specialized meetings organized by the Section as part of the 'new look' programme for the present session.

Two papers on speech links (reviewed on p. 34) were presented, entitled respectively 'Rating of speech links and performance of telephone networks', by Dr. J. Swaffield and Mr. D. L. Richards; and 'Assessment of speech communication links', by Mr. Richards and Dr. Swaffield.

The assessment and rating of speech links is an important subject from the standpoint of telephone engineers, since it has a major influence on the type and cost of the line plant provided. In an extensive telephone network such as that of the United Kingdom, the plant concerned might have a value of many millions of pounds, and large economies might be achieved by quite small changes in the type of plant provided.

The first speaker, Dr. Swaffield, discussed the problem of providing a telephone system in which no more than reasonable mental or vocal effort had to be used in any conversation; this led to study of the mechanism of conversation over a speech link and to laboratory tests (known as assessments) using subjects to determine performance in terms of certain defined criteria.

He described a general assessment method, showing that certain well-tried methods such as 'articulation', 'immediate appreciation', etc. could still be safely used but under restricted conditions. Even the general assessment method, however, was of little value for indicating the merit of an actual link from the user's standpoint but was primarily a means of facilitating realistic comparison (known as rating) of such links with a 'standard speech link' made up of components representative of those used in service.

Mr. Richards then described the laboratory assessment procedures and illustrated their application to a specific rating problem, namely the determination of the maximum lengths of various gauges of local lines when a new subscriber's set of improved efficiency is introduced into a telephone network containing older, less effective, subscribers' sets, maintaining the same over-all standard of performance.

The discussion opened with a vigorous attack by Prof. Colin Cherry, who wanted the first four pages and one of the figures deleted from one of the papers. He suggested that engineers had, for some time, been trying to stretch familiar concepts too far in assessing speech links and that there was an urgent need to seek the advice of the behaviourist psychologist in developing more refined testing methods.

Another speaker said that the 'immediate appreciation' testing method was still a useful one, and, in his view, it gave a significant result without the need for an absolute standard.

The use of civil servants as a basis of the testing team used in arriving at opinion scores was considered by one speaker as not altogether suitable, since they were not a representative sample of the community as a whole; it was pointed out, for example, that people over 60 years of age often used the telephone network, and they were more concerned with adequate signal strength than with signal/noise ratio. It was also suggested that the room-noise levels now experienced were in general higher than those referred to in the papers, since noise due to traffic, road drills, etc. was higher and had not been compensated by architectural improvements in sound absorption.

The question of applying the testing methods to radio-telephone circuits in which the transmission conditions may not be stable, owing to fading and multi-path propagation, was also raised.

Another speaker pointed out that switching engineers concerned with the design of electronic exchanges were, for the first time, now concerned with the possible effects which could be introduced on speech transmission by the exchange equipment.

The authors put up a spirited defence on those sections of their papers which had been criticized, notably by the opener of the discussion. In particular, the controversial Fig. 4A of the paper by Mr. Richards and Dr. Swaffield was defended on the grounds that it conveyed a clear idea of the complete transmission loop around which 'information' flowed; this became particularly relevant when the transmission conditions were poor. The concept of bits per second for measuring this information flow was not unsatisfactory, although measurement was difficult.

Owing to lack of time, it was not possible to reply in detail to all the contributors to the discussion, and the authors agreed to do this in the written version of their reply.

Finally, it is of interest to note that, although the meeting concerned was regarded as one in the specialist category, it was very well attended, and there was in fact difficulty in finding sufficient seating accommodation. W. J. B.

Artificial dielectrics

Artificial dielectrics were the subject of the meeting on the 24th November, and three papers were presented. These were 'The use of dispersive artificial dielectrics in a beam-scanning prism', by Drs. J. S. Seeley and J. Brown; 'The quarter-wave matching of dispersive materials', by Dr. Seeley; and 'Theory of reflections from the rodded-type artificial dielectric', by Mr. A. Carne and Dr. Brown. The papers are reviewed on p. 38.

As the chairman, Mr. Terroni, explained in opening the meeting, the evening had been set aside for the presentation and discussion, on an informal basis, of the first group of a number of specialized papers to be dealt with during the session. He hoped that as many of those present as felt so inclined would take an active part.

About 30 persons attended, perhaps a disappointingly small number, but the obvious enthusiasm of the individuals who contributed to the discussion, coupled with the rather more intimate atmosphere of the tea room, in which the meeting was held, established the success of the evening.

The papers were introduced by Dr. Seeley and Mr. Carne, while most of the questions arising subsequently were answered by Dr. Brown. These questions were mainly directed towards clarifying points made in the papers.

Some highlights came from Mr. Millington, who wanted to know what arrangements were proposed, in the beam-scanning application, to deal with the frequency-modulated wave when it reached the receiver, bearing in mind the wide frequency swing required. Dr. Brown admitted that this was a tricky problem, but he pointed out that it might be resolved either by a corresponding modulation of the receiving system or by a bank of fixed aerials and their associated receiving circuits combining to cover the spectrum.

There were a number of interesting questions and answers about the mechanical tolerances obtainable in the manufacture of these artificial dielectrics and the permissible variations in this respect if the desired electrical characteristics were to be achieved.

A very significant remark was made by Mr. Fuge, again in connection with the scanning application, when he asked what provision was envisaged for avoiding spurious disturbances of the position of the emergent beam, which he pointed out was likely to be highly sensitive to small changes in the operating conditions and particularly so to the maintenance of a stable artificial-dielectric structure. In reply Dr. Brown suggested that, as in similar applications, it would probably be necessary to apply a feedback control of the beam swing.

The meeting continued in active discussion of the three papers until about 7.15 p.m., when the chairman brought the proceedings to a close with a vote of thanks to the authors and to those who had taken part in the discussion with such illuminating results. H. M. B.

La soirée

The Oxford English Dictionary defines 'soirée' as (swar.ā) n.—'social evening, evening gathering, esp. for music,

Quite comfortable?

A member adjusts the safety belt on an ejector-seat model at the R.A.E.

conversation, the advancement of some society's objects, or the like'.

The Radio and Telecommunication Section Soirée seemed

Dr. and Mrs. J. S. McPetrie talking to Frances Day, no doubt on a topic concerned with management

to come nicely under the definition; perhaps less esp. as regards music, certainly more esp. for conversation, and probably most esp. for laughter; in sum, it did much to advance a few aspects of what we trust are some of the Section's objects; as to 'the like', there were the interesting technical exhibits.

The venue was the Royal Aircraft Establishment at Farnborough, where we saw equipment in which electronics was put to the service of aviation and we learned that there was also to be a B.B.C. recording of a programme entitled 'How to manage men'.

It must be confessed that the writer of these notes, having been early in life indoctrinated with B.B.C. atmosphere, expected the recording to constitute some kind of a lecture on management in the sense of 'Admin.'; it turned out, however, that it was to be, rather, a demonstration of matriarchy—therefore more in the sense of 'Admum'—five women were to say how to manage men, and one unmanageable man was to reply.

In the upshot the title could well have been 'Where was Moses when the light went out?' or 'Is there an electrical engineer in the house?' Assembling, after a farinaceous fill-up at a cold buffet, to listen to the recording at 7 p.m. precisely, nothing happened until at 7.10 p.m. we were told to be patient—there was a technical hitch. Another ten minutes passed, and the hitch was explained as a blown fuse in the stage-lighting circuit, an announcement rounded off by mocking laughter. In another ten minutes we were told that we would have to wait an hour.

There is no need to underline the situation; it may be imagined how the wifely contingent giggled; how often it is, when a fuse blows, that the wife of an electrical engineer has to find the candles, the wire, the pliers, and in the end has to do it herself. With no woman to help, it took an hour to repair the fault, but it was no one's fault really—the breakers had come out in the substation.

The show must go on; it did; we laughed a lot. Perhaps Frances Day was a little more pleased with herself than we with her. Perhaps the innuendo raised some elderly eyebrows. Perhaps we envisaged a rather laborious editing of the recordings; nevertheless we admired Miss Charmian Innes for her wit, we laughed, we applauded: we were a good studio audience.

Our thanks are due and were nicely given by our Chairman to the organizers, to our hosts, and to all, including that substation breaker, that made this Soirée esp. entertaining.

P. P. E.

UTILIZATION

Splitting the infinitive

AT the meeting on the 13th November Messrs. J. W. Binns and W. J. Outram presented their paper entitled 'Electrification of the U.K.A.E.A. Industrial Group factories', which describes some of the special electrical requirements and problems at these establishments and also deals with the three main groups of the Authority's activities, namely chemical plants, diffusion plant and nuclear reactors. A review of the paper appears on p. 40.

The need for a high standard of cleanliness and ventilation throughout was discussed, as also was the maintenance of cooling systems and safety circuits for reactors. Consideration was given to some of the special electricity-supply problems which arise, and the Authority's general policy on standardization and electrical safety was set out.

The discussion was opened by Mr. D. B. Hogg, who referred to the background of heavy chemical research in this country, which had made possible the things described in the paper, and also alluded to the 'heavy blanket of secrecy' which still existed in radioactivity safety measures.

The subject-matter of this paper naturally stimulated a discussion over a very wide field, in which many participated, covering such aspects as radioactively contaminated motors, magnetic pumps using liquid sodium, reliability and continuity of supply, and power-factor correction.

It was interesting to hear one speaker express the view that the more clever a thing was the more likely it was to go wrong—a dictum which, no doubt, found a ready echo in the experiences of many of those present. Another speaker, evidently of a grammatical turn of mind, pointed out with unconcealed glee a particular portion of the text which contained 'a wonderful split infinitive'.

An important omission commented on by one contributor to the discussion was lightning protection and the special arrangements which might be necessary in this connection in sealed containing buildings of the Dounreay type.

Listening to the reading of this particular paper and the discussion which ensued, in which many references were made to 132kV and even 275kV, one could not help remarking on the considerable distance the Utilization Section has indeed

travelled since the days of its formation only a few years ago when no doubt its sister Sections considered its potential was merely 'l.v.'. R. H. R.

Adequate wiring

The large attendance at the Symposium on the Provision of Adequate Electrical Installations in Buildings on the 27th November demonstrated a lively interest in this subject throughout the industry and profession.

Attention was drawn to the two aspects of adequacy, expressed as 'technical adequacy' and 'user adequacy' respectively; the former is the more closely related to proper design technique, while the latter normally forms the subject of the user's, or his architect's or consultant's, specification. Much of the discussion centred on the general lack of user adequacy, which is especially apparent in domestic installations.

Unfortunately, the practice of many local housing authorities lags far behind the recommendations of the Ministry's Housing Manual, 1949, let alone the higher standards envisaged by the Post-War Building Study Committee convened by The Institution in 1943.

Speaking as an architect in the Ministry of Housing and Local Government, Mr. P. G. Negus, A.R.I.B.A., said that the final choice was invariably left to the local authority, but in fact the practice of the L.C.C., as described in the paper by Mr. C. A. Belcher, measured up well with the Housing Manual.

He agreed that a higher standard might now be necessary and that perhaps the time had come for the Ministry of Housing and Local Government to raise its standard recommendations; if such a task should be undertaken, the record of the papers presented and of the discussion would afford very valuable material for consideration by those who would have to deal with the matter for the Ministry.

In the general discussion it was emphasized that nowadays a television set is expected in even the humblest home and that all the tendencies of the moment, such as younger marriages, increasing demands for married women in employment, higher purchasing power, easier credit facilities and the increased number of old people living alone, indicated the need for more and more socket-outlets in the home, both now and in the future.

Electrical installation work in domestic premises accounted for only 2% or 3% of the total building cost, and in some cases the number of outlets could be doubled for as little as 0·1% increase in actual building cost. Adequate installations greatly enhanced the comfort and happiness of any building occupier, whereas inadequate installations led to hazards of overloading and amateur extensions, which greatly increased the risk of fire. In fact, fires attributed to faults in switchgear, cables and flexes amounted to a total of 2800 a year in the United Kingdom.

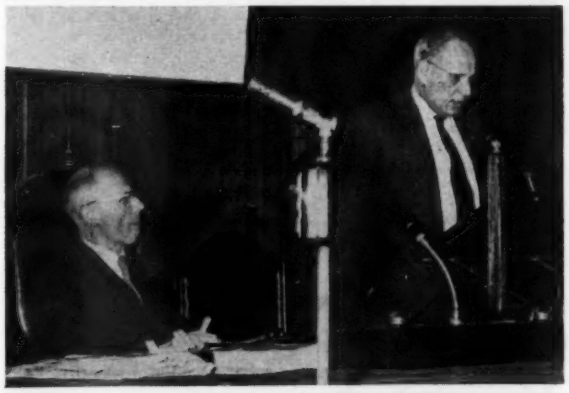
Reference was made by Col. B. H. Leeson to the steps that were already being taken within the industry to launch a publicity campaign next spring for more adequate installations, and it had been hoped that the presentation of the symposium would afford a suitable opportunity for sorting out any differences of opinion that might exist among engineers as to the technical means of achieving more adequate installations economically.

Space does not permit giving even a summary of the many recommendations made both in the papers presented and in the discussion, but there is no doubt that the record of the proceedings will provide a valuable guide to those who will be organizing the campaign and useful material for consideration by committees and others dealing with the subject.

In the meantime it does seem that it would be possible to draw up some form of code or guide for use by architects and others concerned in the preparation of specifications.

As Mr. R. Baldwin emphasized, there appears to be an urgent need for a simple but comprehensive guide to 'user' as distinct from 'technical' adequacy, and we may hope that this will be incorporated in the scheme now in hand. For guidance with regard to commercial and small industrial installations, one cannot do better than refer directly to the very excellent papers presented by Mr. E. E. Jacobi and Mr. J. A. Sharp, which called forth little comment in the discussion.

As has been said before, it remains especially the responsibility of members of the Utilization Section to press upon all concerned with any form of building construction the urgent need for more adequate electrical installations, which are at the present time so very much in the best interest of the community we serve. R. A. M.



Mr. Colin C. Hyams presenting his paper on 'Houses'

The Chairman's message

The paper on 'Electrification of the U.K.A.E.A. Industrial Group factories', presented by Messrs. J. W. Binns and W. J. Outram, attracted a good attendance and an interesting discussion, as might have been expected.

The development of nuclear power and its application to electricity supply is a matter of increasing concern to the nation as a whole, and in view of the foreseeable need for more and more nuclear generating plant, the utilization of electricity in nuclear power stations is a subject of growing interest to the Section.

So far, there has been little available information as to practical experience in this field, and so the paper presented on the 15th January by Messrs. N. J. Mackay and E. Hardwick on 'Electrical installation at Calder Hall nuclear power station' is very welcome. Following later, there is another paper, to be given by Mr. D. A. Watt, on a closely related subject 'The design of electromagnetic pumps for liquid metals'.

I should like to conclude on a personal note, by wishing all of you success and happiness in this New Year and in expressing the hope that I may have the pleasure of meeting a great many of you again at the Section Dinner-Dance on the 16th January at the Café Royal. R. A. MARRYAT

SUPPLY

Relations are never far apart

THE wide scope of the Section covers the generation of electricity from primary energy sources, the transmission of electricity at high voltage, and the distribution of electricity to the consumer. The related interests, such as alternators, transformers, switchgear, cables, overhead lines, and their ancillaries, are readily apparent.

Also coming within the scope, less obvious but nevertheless important aspects of supply engineering are often encountered, an example being the papers read at Savoy Place on the 26th November, when arc physics in connection with surge problems was touched on. Furthermore, such diverse subjects as corrosion, hydrocarbon oils and meteorological effects on power systems also receive attention, and members can hear most valuable views from experts in these many associated fields.

In 1959

The London programme for the second half of the session shows that the activities will delve into problems associated with high-voltage air-break circuit-breakers, transformers and power-station auxiliaries. As indicated below, the Annual Lecture and social events are planned, and they should prove of wide interest.

Dinner-Dance. This popular annual event will take place on the 11th March at the Connaught Rooms, London.

Annual Lecture. The Section is extremely fortunate in expecting to welcome Mr. Philip Squire, deputy technical director of the World Bank, who will lecture on that organization in terms of 'what it is and what it does'. The Annual Lecture is always regarded as one of the highlights of the session, and this year again it should be found highly interesting and informative.

Day Visit. Plans for date and place are proceeding apace, and an early notice can be anticipated.

The Emerald Isle. In September, at the invitation of the Irish Branch, the Section expects to visit Dublin, and an attractive programme is in formulation, the preliminary details of which will be available shortly.

F. C. W.

LONDON REPORT

DISTRICT MEETING AT OXFORD

Shooting high

THE session was opened with a most successful meeting held on the 8th October, when Dr. R. L. F. Boyd presented a paper entitled 'Rockets and satellites' to an audience of 72 members and visitors. Mr. R. Carruthers took the chair.

Until comparatively recently the knowledge of the upper atmosphere was somewhat scanty, and Dr. Boyd showed how new developments were being used to improve our knowledge as part of the research programme for the International Geophysical Year.

The pioneer work of Appleton and others using radio waves reflected from charged layers gave only somewhat generalized information up to altitudes from which reflections could be obtained. To make observations above this height it was obviously necessary to carry apparatus up into these regions.

Dr. Boyd described many interesting observational techniques developed to perform in miniature, but with rather restricted scope, measurements usually conducted with much larger conventional laboratory apparatus. A major problem was that of lifting the apparatus into the upper atmosphere, and the development of techniques, from the high-flying balloon, through 'rockoons' to rockets, and latterly to artificial satellites, was described.

A lively discussion followed the paper, and Dr. Boyd took the opportunity of commenting on the present excessive interest in space travel, which tended to distract effort and attention from the more real and immediately valuable research uses to which rockets and satellites could be put.

Mr. B. Wise moved a vote of thanks to Dr. Boyd, which was enthusiastically supported.

The Convener of the District, Mr. J. L. Taylor, presented the report of the organizing committee covering the 1957–58 Session and gave details of the programme for the present session.

R. C.

DISTRICT MEETING AT READING

Fuel efficiency

MR. R. G. HENBEST took the chair at the first meeting of the 1958–59 Session on the 13th October for a talk on 'Fundamentals of fuel efficiency in the generation of electricity', given by Mr. P. Lewis. Mr. R. Wood was unable to give this, owing to a sudden family bereavement.

Mr. Lewis opened his talk by referring to the importance of the efficient use of fuel in the industry, from both the economic and the atmospheric-pollution points of view.

He drew attention to the four fundamentals on which fuel efficiency depended, namely the type of fuel used; the type of plant; operation of the plant; and utilization of the plant.

Dealing first with the fuel, he gave details of the physical and chemical characteristics of both coal and oil and explained their effect on combustion and their resulting products of combustion. He explained the different methods of burning coal, and gave a brief description of a typical plant as used in electricity generation.

On the operation of plant, he dealt with the pretreatment of fuel as an aid to combustion and the need for and the proper control of excess air and its effect on losses. He detailed the four principal losses and described instrumentation and means for their control. Reference was made to the costs involved in departures from optimum efficiency and to the effects of SO_2 as a product of combustion of the sulphur constituent. Finally, he considered the utilization of plant and how the load factors of operation affected combustion efficiency.

During the ensuing lively discussion, questions arose on methods of combustion control, the efficiency of the steam cycle and the effects of automatic operation of plants.

The speaker was warmly thanked by Mr. H. R. J. Baigent for a most interesting talk and for so kindly undertaking to give this in Mr. Wood's absence at only a few hours' notice.

R. H.

MERSEY AND NORTH WALES CENTRE

Annual Dinner

ON the 3rd November 1958, Mr. John Collins, Chairman, presiding, the Annual Dinner of the Mersey and North Wales Centre was held for the fourth year in succession at the Grosvenor Hotel in the ancient city of Chester.

In proposing the toast of The Institution, the Rt. Rev. The Lord Bishop of Chester, Dr. G. A. Ellison, M.A., at once established a bond of union with his audience by disclosing that he was related to the late Lord Kelvin—probably unaware that to the memory of his illustrious relative was attached the unique distinction of having held the office of President of The Institution on three occasions.

Dr. Ellison, in a philosophical discourse of considerable interest, referred to the conflict between religion and science which existed during the latter part of the last century and went on to remind us of how much they have in common—each striving to establish the truth and so moving towards a common goal.

He said 'The old barriers between religion and science are being broken down, and we are beginning to appreciate better what the other is trying to achieve. Scientific men are beginning to realize the impact religion can have on what they are doing, and religious men are prepared to recognize the enormous advancement of science.'

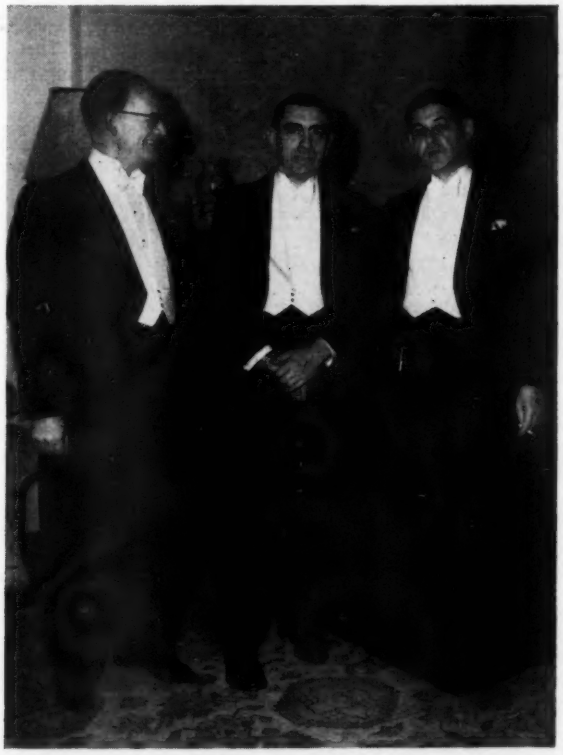
The Lord Bishop of Chester proposes the toast of The Institution

On his left is Prof. J. M. Meek, Past-Chairman, and on his right can be seen (r. to l.) Mr. John Collins, Chairman, Mr. T. Makin, Past-Chairman, and Mr. E. B. Banks

The Church, he said, was concerned at the effects of industry in two particular respects—the growing importance attaching to the machine as compared with the individual, and the effect of three-shift working on family life.

Mr. A. H. Mumford, a Vice-President, responded on behalf of The Institution. After a statistical survey and a reference to the structure of The Institution built on the four specialized Sections, Mr. Mumford stressed the need for more lectures of general interest, freed from excessive detail, and in such form as would be comprehensible and attractive to the general membership. He expressed hopes of the benefits that may result from the formation of the Medical Electronics Discussion Group, to consider, with the medical profession, their common problems.

We were pleased to welcome among our guests Mr. E. B. Banks, chief commercial manager, and Mr. F. R. Smith, general manager, of the English Electric Co. Ltd.; the representatives of kindred institutions and societies; and the Chairmen of several of our own Centres and Sub-Centres. It gave us special pleasure to see present two Past-Chairmen of the Centre, Mr. T. Coates and Mr. E. G. Taylor, who had emigrated to Manchester some years ago and now returned for this reunion.



Annual Dinner of the Mersey and North Wales Centre at the Grosvenor Hotel, Chester, on the 3rd November 1958

This group shows Mr. John Collins, Chairman of the Centre, Mr. A. H. Mumford, a Vice-President, and Mr. T. Makin, Past-Chairman

The toast of the guests was proposed in a refreshing and characteristic speech by Mr. T. Makin and acknowledged on behalf of the guests by Mr. E. B. Banks.

Forthcoming engagement

The Annual Dinner-Dance will be held on the 13th March 1959 at 7 p.m. at Hulme Hall, Port Sunlight. E. W. A.

NORTH STAFFORDSHIRE SUB-CENTRE

Chairman's Address

THE first meeting of the session was held at Stone on the 10th October 1958. Mr. H. A. P. Caddell, who was chairman for the first part of the meeting, presented the Graduate and Student Premium Certificate to Mr. G. E. Moreton for his paper on 'The short-circuit testing of electrical equipment' and formally welcomed four new Corporate members.

He then referred to the result of the questionary recently submitted to members to ascertain their views on the activities of the Sub-Centre. This indicated that the present arrangements were generally acceptable, but there was some demand for a summer outing and also for a discussion meeting. These would be considered by the Committee when arranging the programme for the second half of the session.

A cordial welcome was extended to Mr. J. Ashmore, Chairman of the South Midland Centre, who complimented the Sub-Centre on being live and active and wished it every success in the coming session. Mr. Caddell then introduced Mr. R. W. Palmer as the Chairman for 1958–59 and invited him to deliver his Address on 'Electrical engineers and electronics', in which he traced the history of electrical engineering.

He pointed out that 'light current' work had developed to the transatlantic-telegraph stage before electric light was invented. Heavy-current engineering then developed rapidly, until now a state of relative saturation has been reached and electronics is forging ahead. He then considered the impact which electronics and nuclear physics would have on engineering. (An article based on Mr. Palmer's Address will be presented in a future issue of the *Journal*.)

A vote of thanks to Mr. Palmer was proposed by Mr. A. Asbury, who said the Address encouraged us all to view the whole of electrical engineering in a wider perspective. Mr. Caddell then invited Mr. Palmer to take the chair.

In proposing a vote of thanks to Mr. Caddell, Mr. Palmer said he had brought a particular dignity to the office and that his efforts on behalf of the Sub-Centre had been not only intensive but extraordinarily successful. In reply, Mr. Caddell expressed regret at leaving the Sub-Centre, where he had found many new friends and new interests.

Mr. Ashmore presented copies of 'The history of The Institution' to Mr. Caddell, the retiring Chairman, and to Mr. E. Bolton, the retiring Honorary Secretary. The meeting then closed and was followed by a conversazione.

Cause for alarm

At the meeting held at Stafford on the 27th October, Mr. R. W. Palmer formally welcomed four more new Corporate members. The papers presented were 'The organization of large-scale Grid system tests', by Dr. F. H. Last, Mr. E. Mills and Mr. N. D. Norris; and 'Results of full-scale stability tests on the British 132kV Grid system', by Dr. F. Busemann and Mr. W. Casson. Short reviews of these papers appeared in the June 1958 *Journal*, pp. 319 and 317 respectively.

Mr. Mills read the first paper and then presented a film which showed in a vivid manner the effect on the control-room instruments when instability was caused by the application of various types of faults to the 132kV network. The film also showed the operation of the turbine-governor mechanism when pole slipping occurred. Mr. Casson then read the second paper.

The discussion was opened by Mr. S. E. Newman and ranged over the speed of response of alternator voltage regulators, the testing of networks connected to alternators of 100MW or more capacity, future tests on high-speed reclosers and many other aspects of large-scale testing.

Mr. W. N. Burns, proposing a vote of thanks, congratulated the authors on two very fine papers. He graphically described the scene inside a power station when, because of instability, all the plant shuts down and a deathly silence descends on the station, only to be broken by the strident ringing of all the telephone bells. L. G.

SCOTTISH CENTRE

Romance and electrical engineers

ON the 18th November the Glasgow Dinner-Dance was held under the Chairmanship of Mr. R. J. Rennie. This year the record number of members and guests exceeded 300 by a significant amount, and the resources of the Grosvenor Restaurant, which is undergoing extensive alterations, were severely strained.

The chief guest was the Rev. Nevile Davidson, D.D., Minister of Glasgow Cathedral, who, in proposing the toast of The Institution, seemed to deprecate the elimination by electrical engineers of romantic meals by candlelight and cosy evenings by a flickering coal fire. Dr. Davidson had, nevertheless, taken his task seriously and had read, at least in part, 'The History of The Institution', so thoughtfully provided by the Secretary.

His interest was aroused particularly by Mrs. Ayrton, our first lady member, but he appeared to be somewhat disappointed to find that her important work on the arc had no connection with a vessel appearing in Biblical history. After these mild strictures, however, Dr. Davidson praised the work of electrical engineers in raising man's standard of life but urged them to do all in their power to ensure that the great benefits they were able to bestow were used for the advantage and not for the destruction of mankind.

The reply to the toast was given by Mr. G. S. C. Lucas, O.B.E., a Vice-President. He referred to the ever-pressing problem of educating engineers and stressed the importance of providing an effective training for technicians as well as for chartered engineers, since the former outnumber the latter by about five to one. Mr. Lucas also referred to the Benevolent Fund and urged members to support the extremely valuable work carried out by its Court of Governors.

The customary presentation of the Hutcheson–Winning Golf Trophy was made, with a charming and poetic speech, by Mrs. Rennie to Mr. R. J. E. Paterson, who had won the competition at the Spring Meeting in Pitlochry. Mr. W. Adam, Chairman of the South-West Scotland Sub-Centre proposed, with appropriate anecdote, the toast of the guests, to which Mrs. J. Mendelson, Chairman, Scottish Council of the Electrical Association for Women, replied. She gracefully acknowledged the honour done to herself and to her Association and took the opportunity of publicly thanking the many members who had helped the E.A.W. on the occasion of its recent conference in Scotland.

The final toast, to the Chairman, was proposed by Mr. J. A. Aked, Senior Vice-Chairman of the Centre, who deplored being allowed only 1½ minutes to assess the work of the Chairman over a period of some half-million minutes but nevertheless found time to congratulate him on his skilful long-term planning in arranging for a son to be occupying the chair of the Graduate and Student Section in this particular year. As usual, dancing until midnight completed yet another highly successful Scottish Centre function. E. O. T.

SHEFFIELD SUB-CENTRE

A very good start to a very busy season

No fewer than 215 members and visitors gathered at Sheffield to hear Dr. F. A. Benson deliver his Chairman's Address, 'Origin and growth of electronics'. The Address was repeated at Brigg in Lincolnshire. Dr. Benson had established a high reputation through other lectures and through contributions to discussions, and his audiences were not disappointed in anticipating an absorbing evening.

At the next meeting, in Sheffield, there was again a very good attendance—105—to hear the paper by Mr. E. P. G. Thornton and Mr. D. H. Booth on 'Design and performance of Gas-Filled cables'.

The busy session ahead

There are the customary meetings on the third Wednesday of each month in Sheffield and also meetings on the third Monday of certain months in North Lincolnshire.

On the 22nd January the Sub-Centre will be honoured by a lecture given by Sir Christopher Hinton, K.B.E., F.R.S.

The Faraday Lecture is an ever popular event in Sheffield, the City Hall always being filled to capacity (2500). Sheffield will have two Faraday Lectures during 1959: on the 6th March 'Automation' by Dr. H. A. Thomas, and on the 1st December 'Electric machines' by Prof. M. G. Say.

The annual Dinner-Dance will take place at the Royal Victoria Hotel on the 17th April.

Planning the programme

It is appropriate to explain that the arrangements for the second half of each session are always deferred as long as practicable, as by so doing the papers can be the very latest rather than old ones. The arrangements for the meetings in March, April and May are, at the time of writing, not sufficiently advanced to be published, but it is planned that the papers should be recent and topical.

The Institution Summer Meeting

The Sheffield Sub-Centre and the North Lincolnshire District will be hosts on the 17th and 19th June at the Institution Summer Meeting. Visits are planned to steelworks and laboratories, permanent-magnet factories, electrical manufacturers, silver and cutlery manufacturers, a glassworks, and some of the stately houses of England. The Sub-Centre will, in fact, be on show.

Sheffield Graduate and Student Section

There is again an enterprising programme, with the monthly meetings distributed over most of the important towns in the Centre's area.

Another week-end conference is planned, following the success of the 1958 event. These conferences are each the equivalent of three or four ordinary meetings, including a visit and several full-length papers.

Students' Lecture

Our Chairman, Dr. F. A. Benson, has been selected to deliver the Students' Lecture this session. He will present his lecture on 'Developments in lighting' to Graduate and Student Sections in many centres all over the British Isles.

The Benevolent Fund

It is customary to appeal for the Benevolent Fund and to take a collection at the opening meeting of each session. The collection at Sheffield on the 15th October realized £15.

F. G. T.

WESTERN CENTRE

Utilization Group

THE Utilization Group, under the vigorous Chairmanship of Mr. C. E. Dew, has already had two meetings this session, and these have been well attended. The Section Chairman, Mr. R. A. Marryat, gave his address at the Inaugural Meeting at Cardiff, and the enthusiasm displayed at this meeting augurs well for the remainder of the session.

Last year the Group paid their first visit to Swansea and the West Wales Sub-Centre. It is pleasing to note that, when there was no indication that a similar visit was to be paid this year, a plea for reconsideration was made by the West Wales representatives, and the Group has now agreed to add an extra meeting to its programme. This meeting will be held at Swansea on the 28th February, and though the title of the paper is not yet known we are assured that it will be of local origin.

A further action under contemplation is a Spring Visit sometime after Easter. This will be north of the Bristol Channel, and though the itinerary has not been fixed it might possibly include the Beacons.

On the 26th January Sir Gordon Radley is expected to read his paper on 'A transatlantic telephone cable', and this has prompted the Group to invite the Post Office Electrical Engineers to this meeting as their guests.

The above notes confirm the view that this Group is well and kicking.

D. J. T.

OVERSEA ATTENDANCE REGISTER

DURING the period 18th November to 15th December 1958 the following members called at the Institution building and signed the Attendance Register of Oversea Members:

COOK, H. F. (Nairobi)
DUNCAN-SMITH, F. (Haifa, Israel)
EAGAN, R. H. (Baghdad)
HASSAN, M. (Wah Cantt., Pakistan)
KEELING, A. S. (Baghdad)
KRAMER, J. J. (Västerås, Sweden)
MEADE, J. (Lagos)
MORTIMER, E. L. (Sydney)
PATEL, M. M. (Bombay)
PETTIFOR, P. N. (Johannesburg)
SENGUPTA, P. M. (India)
THOMAS, L. W. (Washington, U.S.A.)
WHITE, C. H. (Kuala Lumpur, Malaya)

Communications from oversea members

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ADVISORY COMMITTEE FOR ELECTRICAL ENGINEERING
F. J. Lane, O.B.E., M.SC. (26.6.58)

BIRMINGHAM COLLEGE OF TECHNOLOGY
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G. F. Peirson (26.6.58)

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H. Shackleton, M.SC. (6.12.56)

BOLTON TECHNICAL COLLEGE
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ADVISORY COMMITTEE FOR ELECTRICAL ENGINEERING
L. H. A. Carr, M.SC.TECH. (5.12.57)

BRADFORD INSTITUTE OF TECHNOLOGY
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G. O. Watson (31.12.36)
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A. Henderson (18.5.39); *C. E. Mills (6.12.51)
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(Deputy, R. S. Orchard, M.A.)

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*J. A. Broughall, B.SC.(ENG.) (7.3.57)

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SUB-COMMITTEE ON SWITCHBOARDS (ELE/10/10)
*T. M. H. Stubbs (7.3.57)

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Further appointment pending

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SUB-COMMITTEE ON MARINE TRANSFORMERS (ELE/51/5)
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TECHNICAL COMMITTEE ON CONSUMER SUPPLY CONTROL UNITS (ELE/57)
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TECHNICAL COMMITTEE ON POWER RATING OF H.F. HEATING EQUIPMENT (ELE/66)
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*E. J. Sutton (12.5.49)
Further appointment pending

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H. C. Spence (31.3.55)

SUB-COMMITTEE ON ELECTRICAL METER SPACE (B/65/1)
H. C. Spence (31.3.55)

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Chairman: C. W. Sowton, B.SC.

CODE DRAFTING COMMITTEE ON MAINTENANCE OF INSULATING OILS (ELCP/22)
Chairman: P. W. L. Gossling
Institution nominee: A. W. Stannett, B.SC.(ENG.)

CODE DRAFTING COMMITTEE ON CLIMATE PROOFING OF ELECTRICAL EQUIPMENT (ELCP/23)
Chairman: B. Donkin, B.A.

CODE DRAFTING COMMITTEE ON MAINTENANCE OF CONTROL GEAR (ELCP/24)
Chairman: S. J. Emerson, M.ENG.
Institution nominee: R. A. Marryat, B.SC.(ENG.) (nominated by the Utilization Section)

CODE DRAFTING COMMITTEE ON MEASUREMENT AND ABATEMENT OF RADIO INTERFERENCE IN AIRCRAFT (ELCP/25)
Chairman: N. G. Anslow

CODE DRAFTING COMMITTEE ON LOADING OF TRANSFORMERS (ELCP/26)
Chairman: H. G. Bell, M.SC.TECH.
Institution nominees:
H. G. Bell, M.SC.TECH. (nominated by Supply Section)
W. S. Lovely, B.SC. (nominated by Utilization Section)

CODE DRAFTING COMMITTEE ON DUST-TIGHT ELECTRICAL EQUIPMENT (ELCP/27)
Chairman: F. H. Mann

CODES OF PRACTICE COMMITTEE FOR MECHANICAL ENGINEERING (MECP/–)
Institution nominee: F. H. Mann (24.6.54)

CODE DRAFTING COMMITTEE ON GUARDING OF MACHINERY (MECP/4)
Institution nominee: F. H. Mann (1.3.56)

CODE DRAFTING COMMITTEE ON OIL-FIRING INSTALLATIONS AND CONVERSIONS (MECP/6)
Institution nominee: H. E. Baker (7.2.57)

CODES OF PRACTICE COMMITTEE FOR BUILDINGS (BLCP/–)
Institution nominee: Forbes Jackson (29.4.54)

CODE DRAFTING COMMITTEE ON DAYLIGHT, SUNLIGHT, AND ARTIFICIAL LIGHT (BLCP/9)
Institution nominee: W. R. Stevens, B.SC. (31.3.55)

CODE DRAFTING COMMITTEE ON LIFTS, HOISTS AND ESCALATORS
Institution nominees:
L. S. Atkinson (15.4.46); H. W. Fulcher (2.12.43)

CODE DRAFTING COMMITTEE ON MECHANICAL REFRIGERATION
Institution nominee: K. J. R. Cocke, B.SC.(ENG.) (4.3.48)

CODE DRAFTING COMMITTEE ON OPTICAL PROJECTION EQUIPMENT FOR SCHOOLS
Institution nominee: V. M. Roberts, B.SC. (8.8.48)

CODE DRAFTING COMMITTEE FOR INDEPENDENT FIRES
(formerly convened by the Royal Institute of British Architects)
Institution nominee: J. I. Bernard, B.SC.TECH. (16.1.47)

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